January 1985

THE NATIONAL SHIPBUILDING RESEARCH PROGRAM

Metal Forming Systems Research

U.S. DEPARTMENT OF TRANSPORTATION
Maritime Administration
in cooperation with
Avondale Shipyards, Inc.
New Orleans, Louisiana

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PROGRAM MANAGEMENT

This report is one of the many projects managed and cost shared by Avondale Shipyards, Incorporated, under the auspices of the National Shipbuilding Research Program. The program is a cooperative effort between the Maritime Administration's office of Advanced Ship Development and the U.S. shipbuilding industry.

Executive administration and supervision were provided by Mr. E.L. James, Vice President, Production Planning, Avondale Shipyards, Incorporated; with Mr. Richard A. Price, MarAd Research & Development program manager, Avondale Shipyards, Incorporated.

Project definition was provided by the members of the Society of Naval Architects and Marine Engineers Panel SP-1 Shipyard Facilities and Environmental Effects and Mr. R.W. Schaffran, Maritime Administration, Office of Advanced ship Development. Technical advise was received from Eugene Aspuru, Manager of Plant Engineering and Maintenance Dept.

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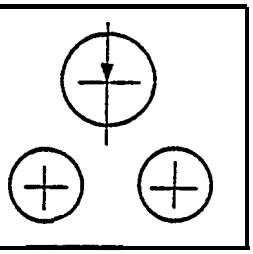
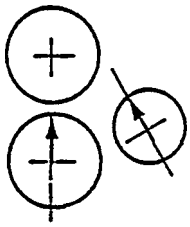
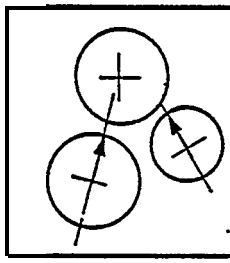
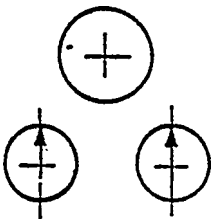
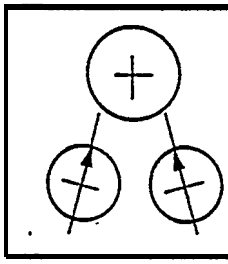
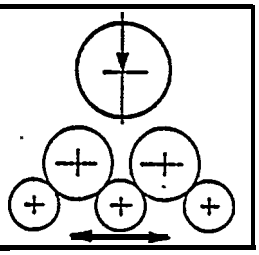
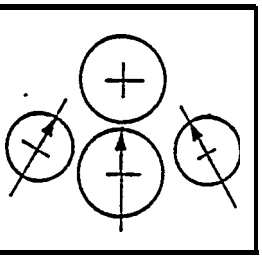
SYMMETRIC PYRAMID [1]			
INITIAL PINCH [IIA]			INITIAL PINCH [Ilb]
PINCH PYRAMID [IIIa]			PINCH PYRAMID . [I I I B)
TWICE INITIAL PINCH [IV]			
TWIN INITIAL PINCH 4-ROLLER [v]			

§ INTRODUCTION §

THROUGHOUT THIS CENTURY, THE PLATE WORKING INDUSTRY HAS SEARCHED FOR IMPROVED TECHNIQUES FOR THE PRODUCTION OF CYLINDRICAL HOLLOW SECTIONS [HEREINAFTER CALLED SHELLS] OUT OF STEEL AND OTHER METAL PLATES.

A SERIES OF DIFFERENT TECHNIQUES AND MACHINES HAVE BEEN DEVELOPED, IMPROVED AND PROGRESSED TO COPE WITH THE EVER GROWING COMPLEXITY OF THIS INDUSTRY. THESE TECHNOLOGICAL CHANGES DEMAND CONTINUOUS ADVANCES IN MACHINERY AND TECHNIQUES TO KEEP UP WITH THE EVER EXPANDING PROGRAMME OF THE PLATE SHOP, BROUGHT ABOUT BY THE USE OF HIGH ALLOY STEEL, CONSIDERABLE INCREASE IN PLATE THICKNESS AND DEMAND FOR HIGH DIMENSIONAL ACCURACY.

THE EVOLUTION BEGAN WITH THE FIRST CRUDE STEPS OF PRESSING PLATES AND THE USE OF PRIMITIVE ROLLING METHODS. THIS DEVELOPED INTO THE MANY OPTIONS AVAILABLE TO US TODAY IN THE SELECTION OF A MACHINE MOST SUITED TO A ROLLING PROGRAMME. IN THIS STUDY WE WILL INVESTIGATE, DESCRIBE AND COMPARE THE VARIOUS ROLLING SYSTEMS, TABULATING THE PROS AND CONS OF THE 3 - AND 4 - ROLLER TECHNIQUES. THE AIM IS TO PROVIDE A BASIS FOR THE SYSTEMATIC SELECTION OF EQUIPMENT MOST SUITABLE IN ALL RESPECTS FOR ANY GIVEN PRODUCTION REQUIREMENT.

FOR COMPARISON PURPOSES THE MACHINES DESCRIBED HEREIN, IRRESPECTIVE OF MANUFACTURE, SHOULD BE TAKEN AS OF THE HIGHEST QUALITY IN THEIR CATEGORY. WE HAVE NO 1NTENTION TO JUDGE THE MERITS AND QUALITIES OF-INDIVIDUAL MANUFACTURERSo

MECHANICS OF PROCEDURE

[1] PRINCIPLE OF PLATE BENDING / ROLLING / PRESSING

[2] CRITERIA OF MODERN DESIGN IN PLATE ROLLING

[3] ROLLER CONFIGURATIONS - 3 ROLLER SYSTEM

[4] Comparison OF DIFFERENT, 3 ROLLER SYSTEMS

[5] DESCRIPTION OF SELECTED 3 ROLLER PLATE BENDING MACHINE

[6] ROLLER CONFIGURATIONS - 4 ROLLER SYSTEM

[7] DESCRIPTION- OF 4 ROLLER PLATE BENDING MACHINES

[8] COMPARISON OF 3 AND 4 ROLLER MACHINES

AND

COMPARATIVE ANALYSIS OF PAY8ACK BETWEEN 3 AND 4 ROLLER SYSTEMS.

[9] CASE STUDIES

[l] THE PRINCIPLE OF PLATE BENDING / ROLLING / PRESSING

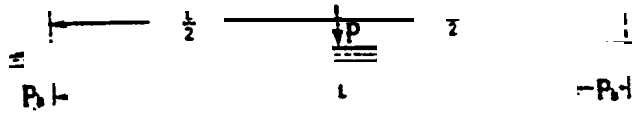
THE PRINCIPLE OF PLATE BENDING IS THE SAME FOR BENDING BY ROLLING OR BY PRESSING:

THREE POINTS OF CONTACT ARE REQUIRED, TWO TO SUPPORT AND ONE TO LOAD. THE LATTER WITH ADEQUATE PRESSURE TO OVERCOME THE ELASTIC LIMIT OF THE PLATE AND ALLOW YIELDING OF THE METAL, BOTH IN STRETCHING OF THE OUTER FIBRES AND IN COMPRESSING THE INNER FIBRES.

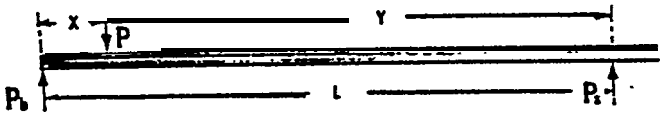
FOR BENDING OF GIVEN "SECTION MODULUS" A CERTAIN BENDING PRESSURE IS REQUIRED, THE FORCE OF WHICH DEPENDS ON THE GEOMETRICAL POINT OF APPLICATION.

THE APPLICATION POINT OF PRESSURE CAN BE:-

[a] SYMETRIC, WHEREBY THE LOAD IS EQUALLY CARRIED BY THE SUPPORT POINTS:

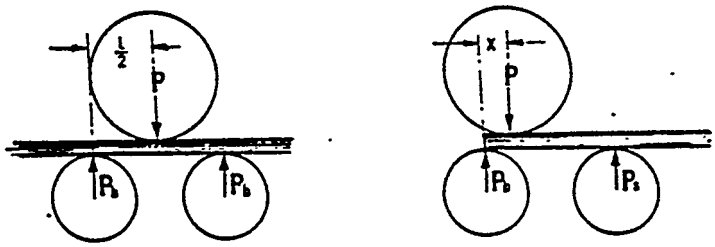


[b] ASSYMETRIC, WHEREBY THE LOAD IS PROPORTIONALLY CARRIED BY THE SUPPORT POINTS



THE ABOVE, WHEN EXPRESSED IN ROLLING IS:

[a] WILL PERFORM ROUNDING EXCLUDING THE END OF PLATE
[b] WILL PERFORM ROUNDING INCLUDING THE END OF PLATE



FOR CALCULATION OF THE FORCE TO BE APPLIED, PLEASE SEE THE FOLLOWING EQUATION:

$$P_b = \frac{M}{X}$$

$$M = \sigma_s \cdot S^2 \cdot W$$

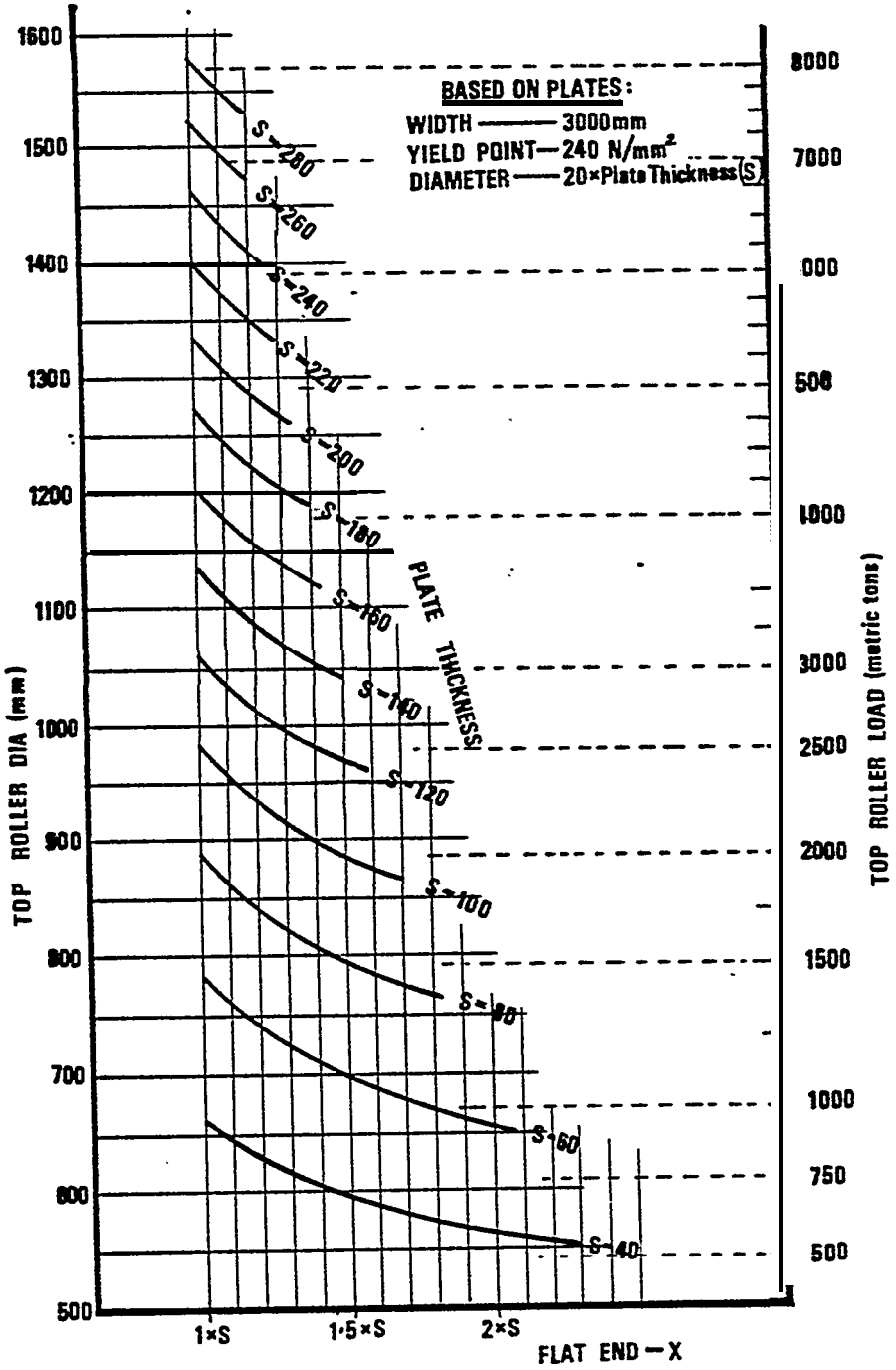
$$P_b = \frac{\sigma_s \cdot S^2 \cdot W}{X}$$

P'_b CORRECTED WITH MACHINE FACTOR K'
[for a Machine of Heavy Construction, should not exceed 3.4]

$$P_b = \frac{\sigma_s \cdot S^2 \cdot W}{X.K}$$

P_b = PRESSURE OVER BOTTOM ROLLER
M = BENDING MOMENT/SECTION MODULUS
X = ACCEPTABLE FLAT-END AFTER ROUNDING
S = PLATE THICKNESS [TH]
σ_s = YIELD POINT
W = PLATE WIDTH

IT IS OBVIOUS, THEREFORE, THAT -THE DESIGN OF A BENDING ROLL, WITH REGARD TO CAPACITY DEPENDS ENTIRELY ON THE ESTABLISHED PRESSURE REQUIRED BY THE 'X' FACTOR . STATED. IN OTHER WORDS, THE PERMISSIBLE FLAT ENDS FOLLOWING ROUNDING.



FROM THE ABOVE, IT IS OBVIOUS THAT SHORTER FLAT END 'X' REQUIRES HIGHER BENDING PRESSUREj INCREASED ROLLER DIAMETER TO RESIST SAME AND THEREFORE HIGHER TORQUE WITH CONSEQUENT INCREASE IN STRUCTURAL WEIGHT AND COST

[2] CRITERIA OF MODERN DESIGN IN PLATE ROLLING

A] STRESS-FREE ROBUST MACHINE FRAME CONSTRUCTION

B] FIRM AND ACCURATE ROLLER POSITONING

c] SELECTION AND MACHINING OF BENDING ROLLERS

D] METHOD OF DRIVE AND COMPENSATED LINEAR SPEED

E] SAFETY AT WORK

A :

MACHINE FRAME SHOULD BE OF ROBUST WELDED STEEL BOX CONSTRUCTION, CORRECTLY SECTIONIZED FOR BALANCED HEAT INPUT CONTROLLED WELDING, PRODUCING A STRUCTURE FREE OF INTERNAL STRESSES AND TENSION. IF SUCH A FRAMEWORK IS NOT PROVIDED, A STRESS RELIEVING OPERATION MUST BE APPLIED.

ALL PLATES USED SHOULD BE LAMINATION FREE WITH A CERTIFICATE TO THAT EFFECT.

PRIOR TO ASSEMBLY, THE MATING SURFACES OF ALL COMPONENTS OF THE WELDED FRAME, INCLUDING ALL MOVING PARTS ARE TO BE FULLY MACHINED TO ISO-R 230 STANDARD.

B :

TO ACHIEVE AND MAINTAIN ACCURACY lN PLATE ROLLING, FIRM ROLLER POSITONING, RE-POSITIONING OR MAINTAINING SETTING IS PARAMOUNT. IN THIS RESPECT THE SLIDE ENHOUSING THE BEARING SHOULD BE SO DIMENSIONED AS TO SECURE AND MAINTAIN ANY SET POSITION, REGARDLESS OF WHETHER THE LOAD APPLIED THEREON IS SYMETRIC OR ASSYMETRIC. ALL SLIDEWAYS SHOULD BE AS SUBSTANTIALLY DIMENSIONED AS THE SLIDE ITSELF TO PROVIDE BACKLASH FREE OPERATION AND COMPENSATE FOR NORMAL WEAR AND TEAR THROUGHOUT THE LIFE OF THE MACHINE.

D :

A MODERN DESIGN SHOULD INCLUDE A POSITIVE INTERNAL AND EXTERNAL ROLLER DRIVE WITH A DIFFERENTIATED LINEAR SPEED IN ACCORDANCE TO THE BENDING RADIUS AND THE THICKNESS OF THE PLATE TO BE BENT. IN OTHER WORDS, TO PROVIDE SPEED COMPENSATION FOR THE INTERNAL AND EXTERNAL CIRCUMFERENTIAL DIFFERENCE OF A SHELL TO BE PRODUCED.

POSITIVE DRIVE SHOULD BE UNDERSTOOD AS A DEFINITE DRIVE BY ALL THE DRIVEN ROLLERS IN ACCORDANCE TO THE LINEAR SPEED AND THE TORQUE REQUIREMENT. THE LATTER BEING THE RESULT OF CONTACT SURFACE DIFFERENCES BETWEEN THE INNER AND THE OUTER ROLLERS, CONCAVE AND CONVEX RESPECTIVELY.

E :

SAFETY AT WORK DOES NOT END WITH THE PROVISION OF GUARDS AND FENCES AROUND THE MACHINE. IT SHOULD BE BUILT INTO THE MACHINE CONSTRUCTION TO CONTROL THE ROLLER SETTING AND THE ROLLER ROTATION GOVERNING THE MOVEMENT OF PLATE PRIOR, DURING AND FOLLOWING THE BENDING OPERATION.

lN OTHER WORDS, TO PROVIDE OMPTIMUM SAFETY FOR THE OPERATOR DURING MANIPULATION OF PLATES AND SHELLS Regardless OF WEIGHT, 5IZE AND GEOMETRY.

AN EQUALLY IMPORTANT PART OF MACHINE DESIGN, IS AN ACCURATE AND RELIABLE POSITIONING DEVICE TO SET AND MAINTAIN ROLLER POSITION FOR CYLINDRICAL OR CONICAL BENDING.

ALL BENDING ROLLERS SHOULD BE EQUIPPED WITH ROLLER BEARINGS, CORRECTLY FITTED INTO SLIDE, WITHIN PREVIOUSLY MENTIONED LIMITS, THUS SAVING ENERGY, AVOIDING HEAT GENERATION AND SIMPLIFYING LUBRICATION.

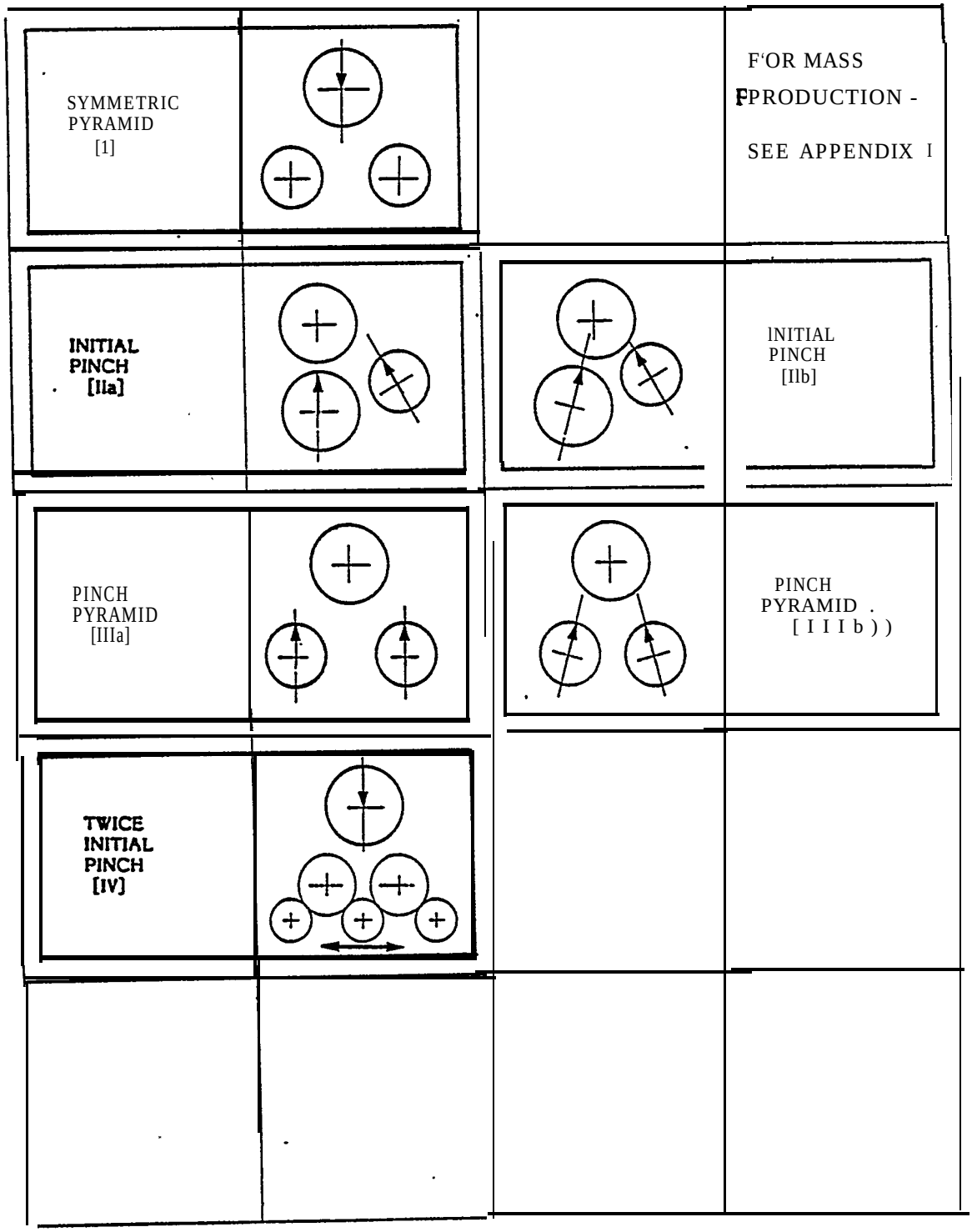
C:

THE BENDING ROLLERS SHOULD BE OF SUITABLY SELECTED STEEL FORGINGS IN ACCORDANCE TO MATERIAL SPECIFICATION OF THE PLATE TO BE ROLLED. CERTIFICATE OF TESTS TO BE AVAILABLE STATING THAT NO FLAWS OF ANY DESCRIPTION ARE PRESENT.

IT IS A NECESSARY EVIL TO CAMBER, AT LEAST, THE TOP ROLLER TO COMPENSATE FOR DEFLECTION DURING BENDING OPERATION. IT SHOULD BE NOTED WHERE A LARGE VARIETY OF SHELLS OF DIFFERING DIAMETERS, WALL THICKNESS, WIDTH AND MATERIAL SPECIFICATION ARE TO BE PRODUCED, THE CAMBERING CAN BE SATISFACTORY ONLY WITH ADDITIONAL SHIMMING.

ALTERNATIVELY, THE DESIGN OF THE MACHINE SHOULD BE SUCH AS TO ALLOW THE FITTING OF INTERCHANGEABLE ROLLERS. PRE-STRESSED TOP ROLLERS ARE COMMONLY USED IN PIPE PRODUCTION WHERE ROLLING LENGTHS ARE 20 FEET OR MORE. SOME MANUFACTURERS ARE NOW INTRODUCING PRE-STRESSING FOR "SHORTER" PRODUCTION MACHINES, COMPLETELY ELIMINATING THE NECESSITY OF CAMBERING.

[3] ROLLER CONFIGURATION -3 ROLLER SYSTEM



ROLLER CONFIGURATION : SYMMETRICAL/PYRAMID [1]

THE ONE TOP ROLLER AND THE TWO LOWER ROLLERS ARE SYMMETRICALLY ARRANGED IN A PYRAMID CONFIGURATION. TOP ROLLER IS VERTICALLY. ADJUSTABLE, LOWER ROLLERS ARE NOT ADJUSTABLE..

ROLLER DRIVE : BASIC DESIGN 2 BOTTOM ROLLERS ONLY
ADVANCED DESIGN ALL 3 ROLLERS WITH COMPENSATED INTERNAL AND EXTERNAL LINEAR SPEED.

OBSERVATIONS :

PLATE EDGES PRIOR TO ROLLING MUST BE PRE-SET BY SEPARATE OPERATION ON PRESS BRAKE OR AUXILLIARY EDGE CURVING MACHINERY. ALTERNATIVELY, ROLL PLATES AND CUT-OFF STRAIGHT PORTION PRIOR TO COMPLETION OF ROUNDING, CLOSE GAP BY FINAL ROLLING OPERATION.

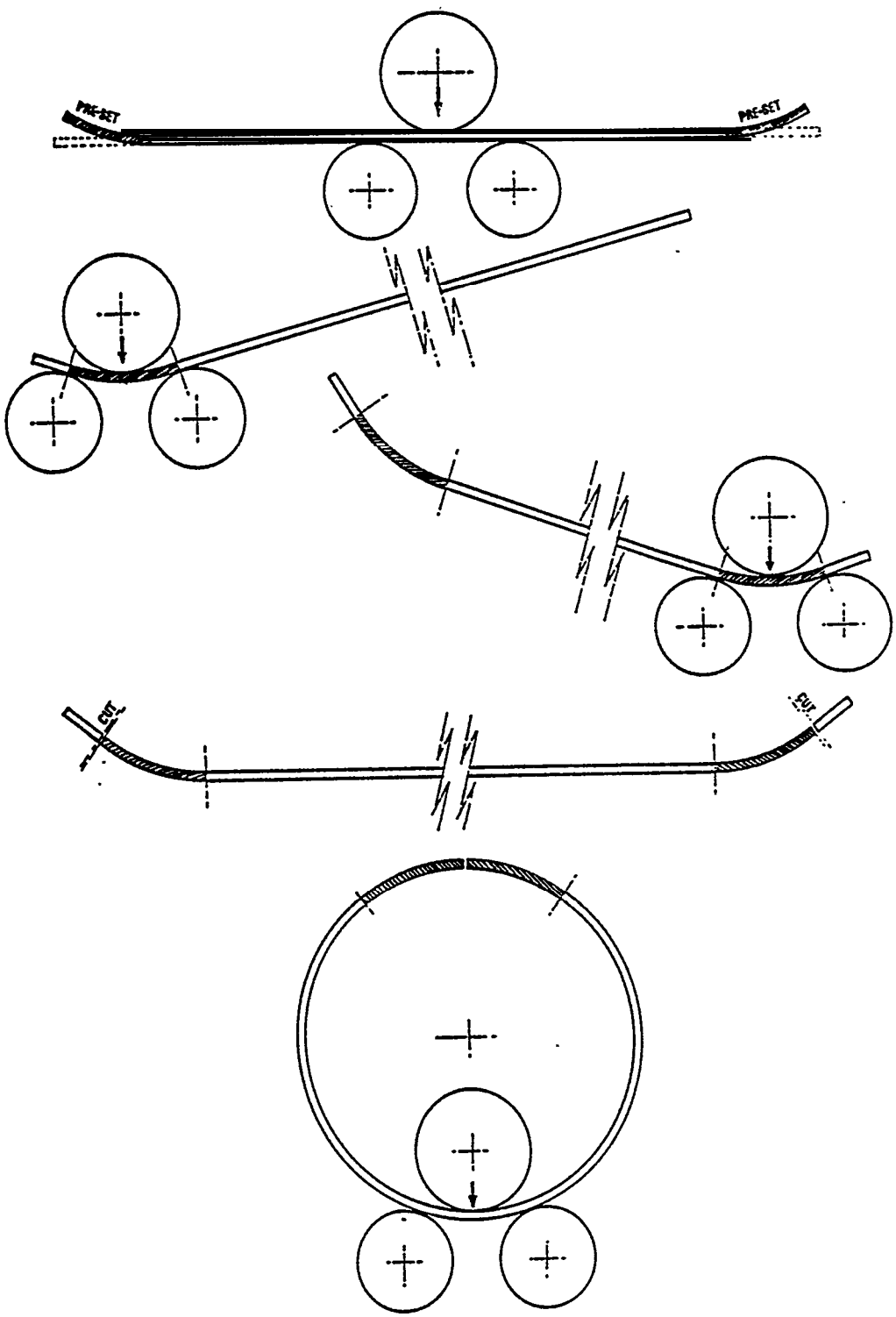
THE MACHINE OF BASIC DESIGN IS MOST SUITABLE FOR LARGE DIAMETER BENDING WORK OR IN AREAS WHERE LABOUR IS PLENTIFUL AT LOW COST, AND SPEED IN PRODUCTION IS NOT OF THE ESSENCE.

COST OF EQUIPMENT - LOW BRACKET

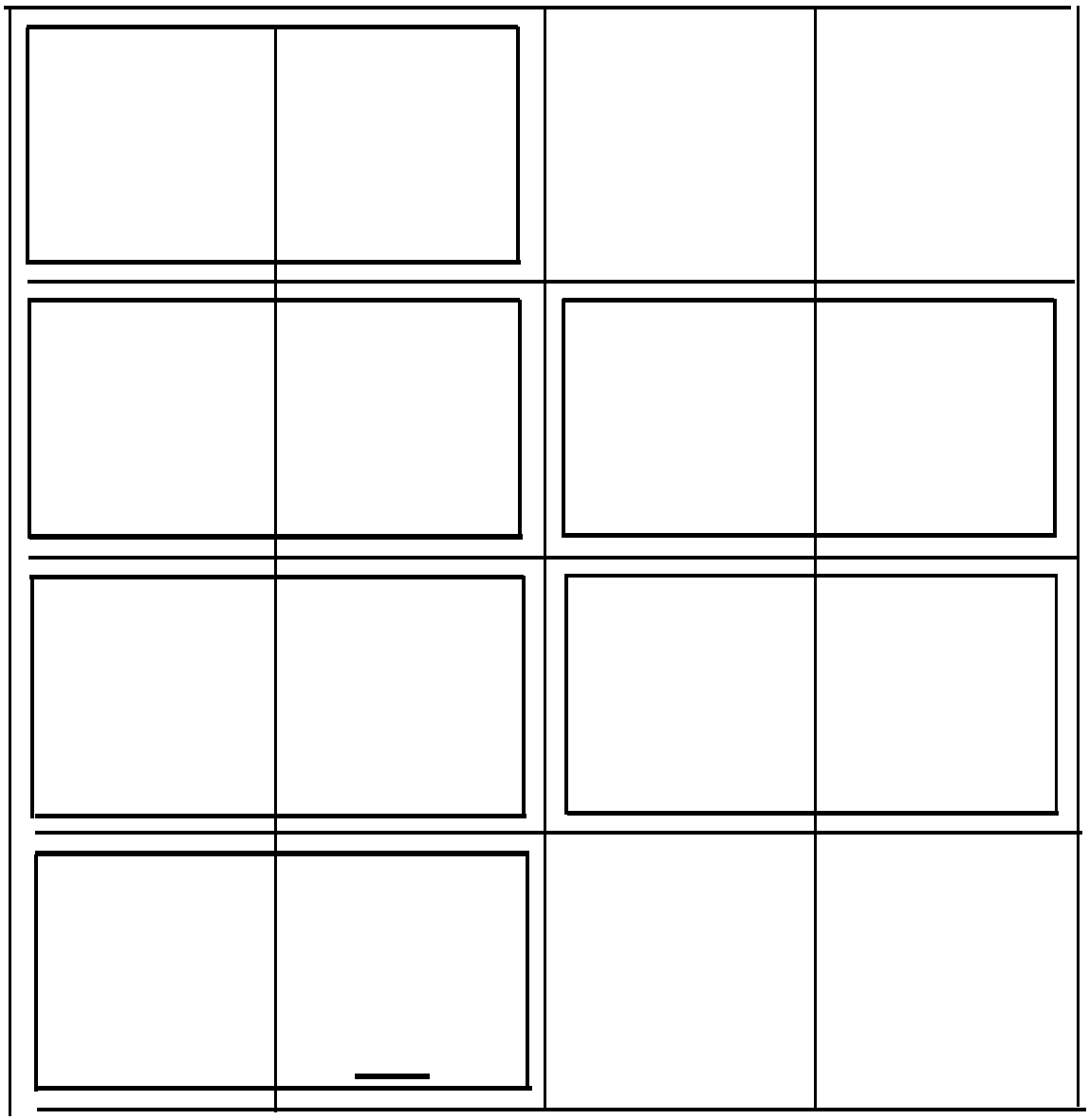
THE MACHINE OF ADVANCED DESIGN WITH 3 ROLLER DRIVE, PRE-STRESSED TOP ROLLER COUPLED WITH AUXILLIARY EDGE CURVING EQUIPMENT IS MOST SUITABLE FOR MEDIUM DIAMETER PIPE PRODUCTION.

COST OF EQUIPMENT - HIGH BRACKET'

CONFIGURATION : SYMETRIC/PYRAMID



[3] ROLLER CONFIGURATION - 3 ROLLER : ASSYMETRIC



ROLLER CONFIGURATION : ASSYMETRIC - 3 ROLLER [II - IV]

THE ONE TOP ROLLER IS IN A FIXED POSITION, THE 2 LOWER ROLLERS ARE SUITABLY ADJUSTABLE TO FORM, WITH THE TOP ROLLER, AN ASSYMETRIC CONFIGURATION.

ROLLER DRIVE : BASIC DESIGN - 2 LOWER ROLLERS ONLY
ADVANCED DESIGN - ALL 3 ROLLERS WITH COMPENSATED EXTERNAL AND INTERNAL LINEAR SPEED.

OBSERVATIONS :

IN PRINCIPLE, PLATE EDGES ARE SET IN THE MACHINE FRONT EDGE PRIOR, AND TRAILING EDGE FOLLOWING, ROUNDING OPERATION., ALTERNATIVELY SET BOTH EDGES PRIOR TO ROUNDING OPERATION. THE PLATE ROLLING PROCEDURE REQUIRES CONTINUOUS SETTING AND RE-SETTING OF LOWER ROLLERS, CLAMPING, RELEASING PLATES, AND IN SOME CASES, EVEN TURNING ROUND PLATE FOR SETTING OF THE OPPOSITE PLATE EDGE. THIS REQUIRES THE EMPLOYMENT OF A SKILLED OPERATOR WITH A HELPER ON THE GROUND AND A DRIVER FOR THE CRANE, AS AND WHEN CALLED FOR [TURNING PLATE].

THE ASSYMETRIC PLATE BENDING ROLL OF 3 ROLLER DRIVE WILL PRODUCE A GOOD QUALITY SHELL WITH REASONABLE TO GOOD EDGE SETTING, ACCORDING TO THE GEOMETRY OF ROLLER SETTING.

COST OF EQUIPMENT - HIGHER BRACKET

ROLLER CONFIGURATION : INITIAL PINCH [IIa]

THE ONE TOP ROLLER IS IN A FIXED POSITION, THE 2 LOWER ROLLERS ARE SUITABLY ADJUSTABLE TO FORM, WITH THE TOP ROLLER, AN INITIAL PINCH CONFIGURATION.

ROLLER DRIVE : BASIC DESIGN - 2 LOWER ROLLERS ONLY
ADVANCED DESIGN - ALL 3 ROLLERS WITH COMPENSATED EXTERNAL AND INTERNAL LINEAR SPEED.

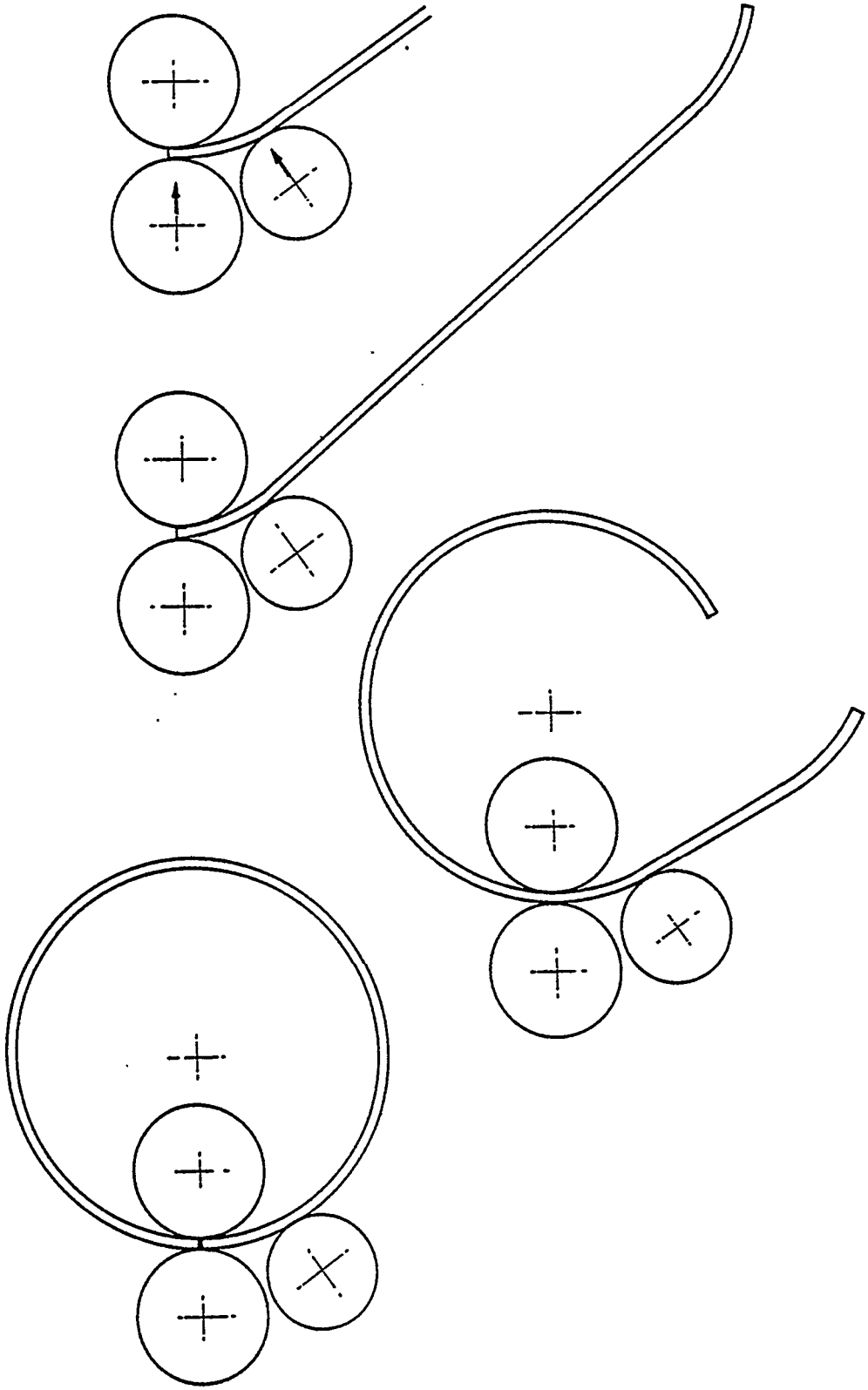
OBSERVATIONS :

PLATE EDGES ARE SET IN THE MACHINE PRIOR TO ROUNDING OPERATION. THE ROLLING PROCEDURE REQUIRES TURNING ROUND PLATE FOR SETTING OF THE OPPOSITE EDGE, REQUIRING THE EMPLOYMENT OF A SKILLED OPERATOR WITH A HELPER ON THE GROUND AND, IN SOME CASES, A CRANE DRIVER.

THE INITIAL PINCH PLATE BENDING MACHINE OF 3 ROLLER DRIVE WILL PRODUCE A GOOD QUALITY SHELL WITH REASONABLE TO GOOD EDGE SETTING. ACCORDING TO THE PLATE THICKNESS TO BE ROLLED WITHIN THE STATED CAPACITY OF THE MACHINE.

COST OF EQUIPMENT - HIGHER BRACKET

ASSYMETRIC Ila



ROLLER CONFIGURATION : INITIAL PINCH [IIb]

THE ONE TOP ROLLER IS IN A FIXED POSITION, THE 2 LOWER ROLLERS ARE SUITABLY ADJUSTABLE TO FORM, WITH THE TOP ROLLER, AN INITIAL PINCH CONFIGURATION.

ROLLER DRIVE : BASIC DESIGN - 2 LOWER ROLLERS ONLY
ADVANCED DESIGN - ALL 3 ROLLERS WITH COMPENSATED EXTERNAL AND INTERNAL LINEAR SPEED.

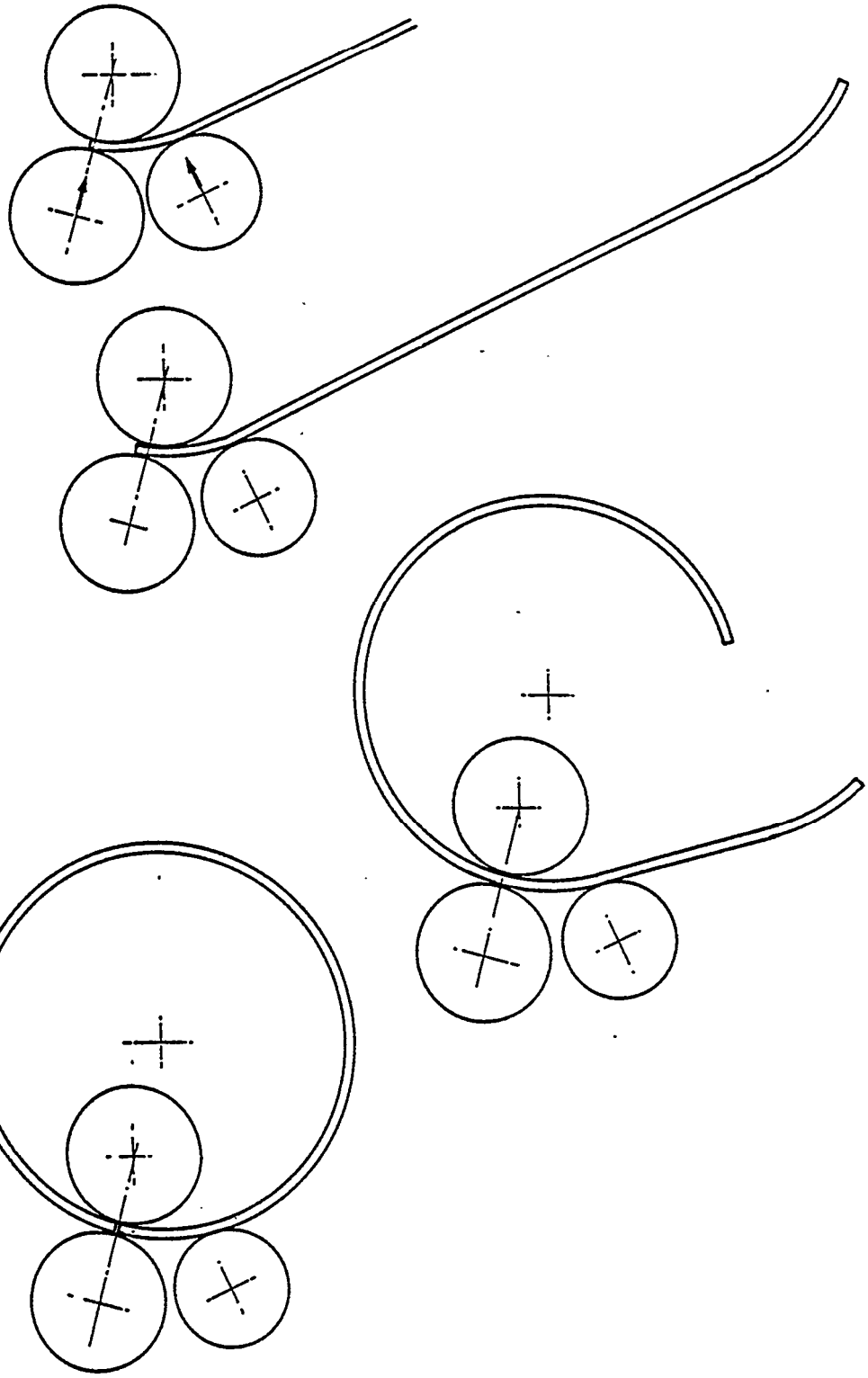
OBSERVATIONS :

PLATE EDGES ARE SET IN THE MACHINE PRIOR TO ROUNDING OPERATION. THE ROLLING PROCEDURE REQUIRES TURNING ROUND PLATE FOR SETTING OF THE OPPOSITE EDGE, REQUIRING THE EMPLOYMENT OF A SKILLED OPERATOR WITH A HELPER ON THE GROUND AND, IN SOME CASES, A CRANE DRIVER.

THE INITIAL PINCH PLATE BENDING MACHINE OF 3 ROLLER DRIVE WILL PRODUCE A GOOD QUALITY SHELL WITH REASONABLE TO GOOD EDGE SETTING. ACCORDING TO THE PLATE THICKNESS TO BE ROLLED WITHIN THE STATED CAPACITY OF THE MACHINE.

COST OF EQUIPMENT - HIGHER BRACKET

INITIAL PINCH IIB



ROLLER CONFIGURATION : PINCH PYRAMID [IIIa]

.

THE ONE TOP ROLLER IS IN A FIXED POSITION, THE 2 LOWER ROLLERS ARE SUITABLY ADJUSTABLE TO FORM, WITH THE TOP ROLLER, A PINCH PYRAMID CONFIGURATION.

ROLLER DRIVE : BASIC DESIGN - 2 LOWER ROLLERS ONLY
ADVANCED DESIGN - ALL 3 ROLLERS WITH COMPENSATED EXTERNAL AND INTERNAL LINEAR SPEED.

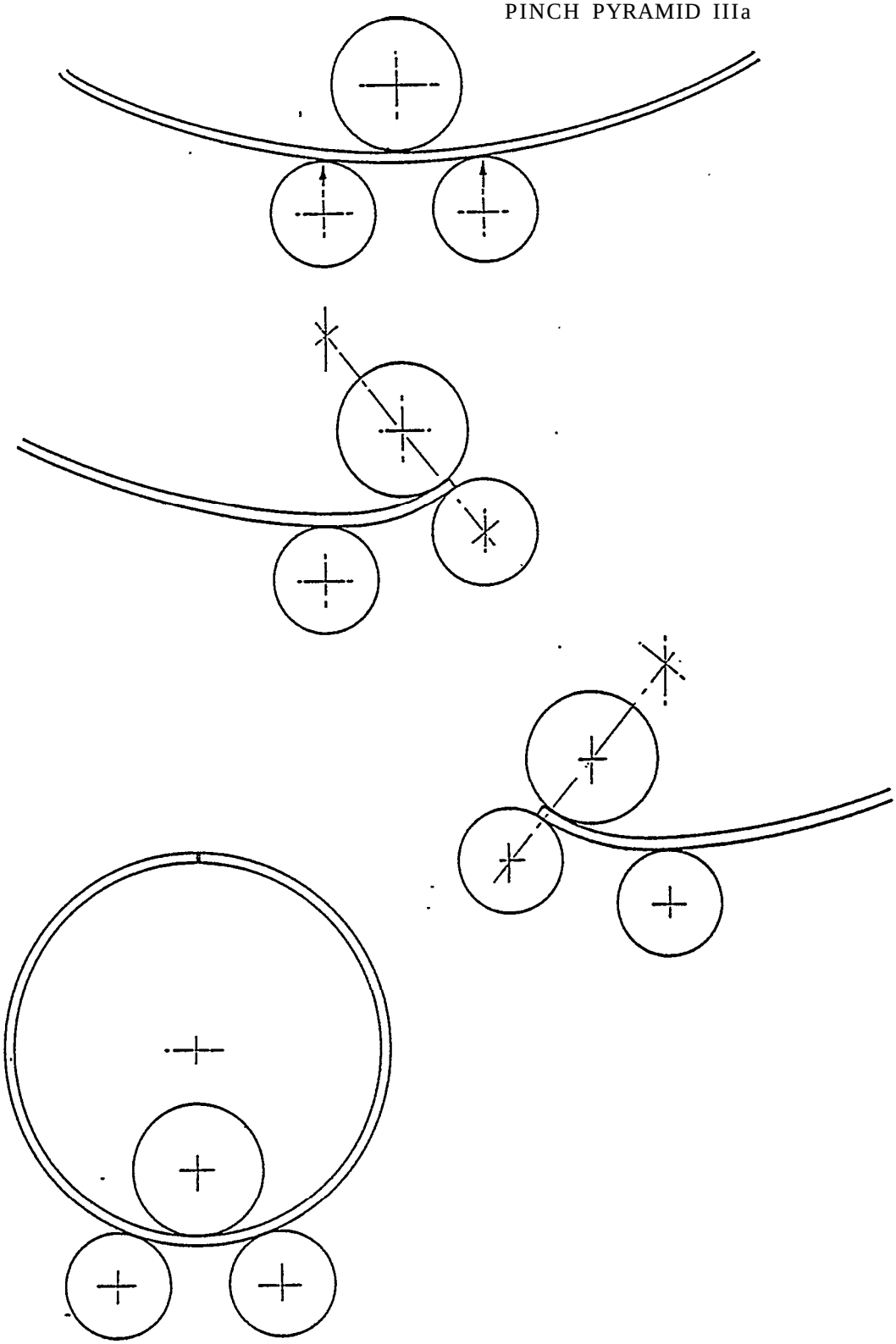
OBSERVA170NS :

PLATE EDGES ARE SET IN THE MACHINE PRIOR TO ROUNDING OPERATION. THE PLATE PROCEDURE DOES NOT REQUIRE THE TURNING OF THE PLATE FOR SETTING OF THE OPPOSITE PLATE EDGE, BUT REQUIRES A NUMBER OF OPERATIONS TO REPOSITION THE PLATE OR PARTIALLY FORMED SHELL AND THE EMPLOYMENT OF A SKILLED OPERATOR WITH A HELPER ON THE GROUND.

THE PINCH PYRAMID BENDING MACHINE OF 3 ROLLER DRIVE WILL PRODUCE A GOOD QUALITY SHELL WITH GOOD EDGE SETTING.

COST OF, EQUIPMENT - HIGHER BRACKET.

PINCH PYRAMID IIIa



ROLLER CONFIGURATION : PINCH PYRAMID [IIIlb]

THE ONE TOP ROLLER IS IN A FIXED POSITION, THE 2 LOWER ROLLERS ARE SUITABLY ADJUSTABLE TO FORM, WITH THE TOP ROLLER, A PINCH PYRAMID CONFIGURATION.

ROLLER DRIVE : BASIC DESIGN - 2 LOWER ROLLERS ONLY
ADVANCED DESIGN - ALL 3 ROLLERS WITH COMPENSATED EXTERNAL AND INTERNAL LINEAR SPEED.

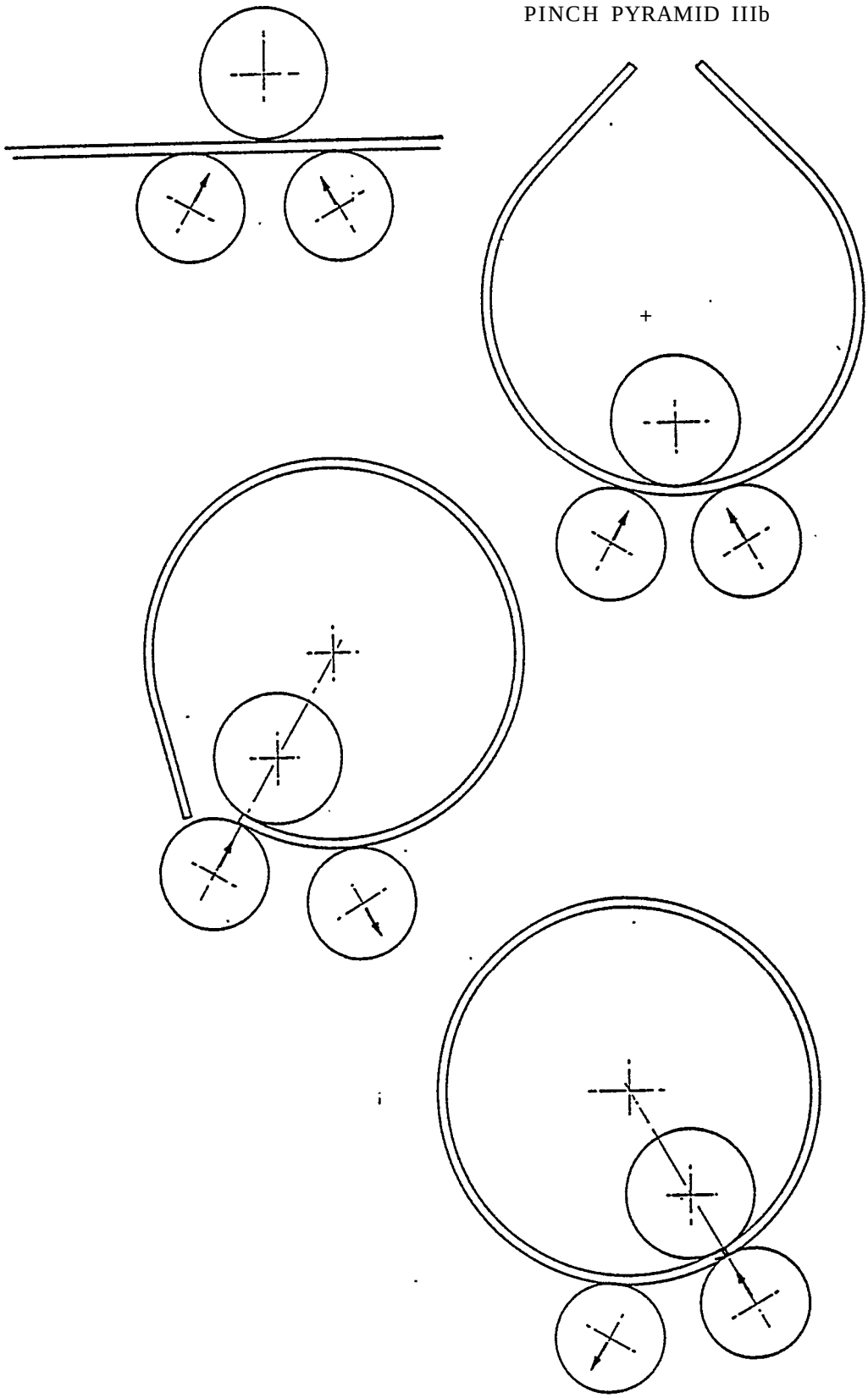
OBSERVATIONS :

PLATE EDGES ARE SET IN THE MACHINE PRIOR TO ROUNDING OPERATION. THE PLATE PROCEDURE DOES NOT REQUIRE THE TURNING OF THE PLATE FOR SETTING OF THE OPPOSITE PLATE EDGE, BUT REQUIRES A NUMBER OF OPERATIONS TO REPOSITION THE PLATE OR PARTIALLY FORMED SHELL AND THE EMPLOYMENT OF A SKILLED OPERATOR WITH A HELPER ON THE GROUND.

THE PINCH PYRAMID BENDING MACHINE OF 3 ROLLER DRIVE WILL PRODUCE A GOOD QUALITY SHELL WITH GOOD EDGE SETTING.

COST OF EQUIPMENT - HIGHER BRACKET.

PINCH PYRAMID IIIb



ROLLER CONFIGURATION : TWICE INITIAL PINCH **[IV]**

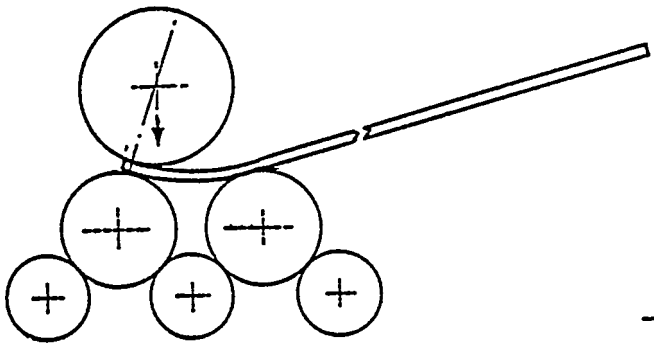
THE ONE TOP ROLLER IS ADJUSTABLE IN THE VERTICAL PLANE THE 2 LOWER ROLLERS ARE ADJUSTABLE IN THE HORIZONTAL PLANE TO FORM, WITH THE TOP ROLLER, A CONFIGURATION OF VARIABLE GEOMETRY.

ROLLER DRIVE : **BASIC DESIGN -** 2 LOWER ROLLERS ONLY
ADVANCED DESIGN - ALL 3 ROLLERS WITH COMPENSATED EXTERNAL AND INTERNAL LINEAR SPEED.

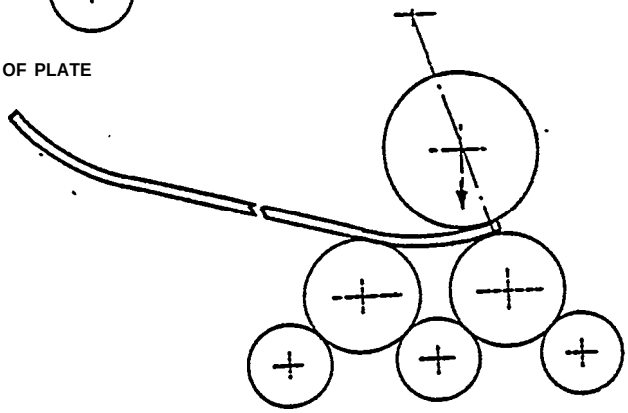
OBSERVATIONS :

PLATE EDGES ARE SET IN THE MACHINE PRIOR TO ROUNDING OPERATION. THE PROCEDURE DOES NOT REQUIRE THE TURNING OF THE PLATE FOR SETTING OF THE OPPOSITE PLATE EDGE, LOWER ROLLERS HAVE TO BE RE-SET FOLLOWING EACH AND EVERY OPERATION HOWEVER, AT. EACH RE-SETTING, THE LOWER ROLLER HEIGHT REMAINS CONSTANT AND PROVIDES AMPLE SUPPORT AND STABILITY FOR PLATE AND SHELL DURING BENDING OPERATION. SKILLED OPERATOR WITH A HELPER REQUIRED. THIS MACHINE WITH 3 ROLLER DRIVE -WILL PERFORM FIRST CLASS QUALITY ROUNDING AND EDGE SETTING OPERATION.

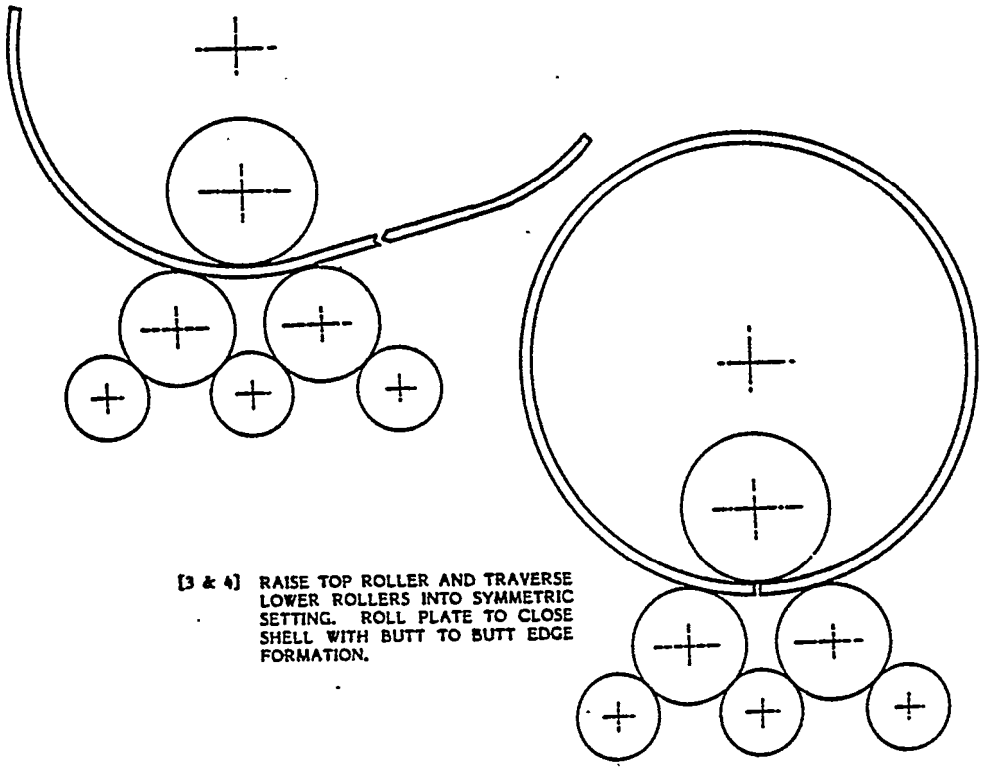
COST OF EQUIPMENT - HIGHER BRACKET



[1] SET LEADING ECCE OF PLATE



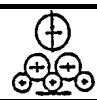
[2] SET TOP ROLLER, TRAVERSE LOWER ROLLERS, ALIGN AND SET TRAILING EDGE OF PLATE.



[3 & 4] RAISE TOP ROLLER AND TRAVERSE LOWER ROLLERS INTO SYMMETRIC SETTING. ROLL PLATE TO CLOSE SHELL WITH BUTT TO BUTT EDGE FORMATION.

CHART 1

BASIC CHARACTERISTICS OF 3-ROLLER MACHINES

TYPE	SYMMETRIC PYRAMID [1]	INITIAL P!NCH [II]	PINCH PYRAMID [III]	TWICE INITIAL PINCH [IVI
ROLL CONFIGURATION				
EDGE SET CAPABILITY	No	YES	YES	YES
TURN & REINSERT PLATE FOR SECOND EDCE SETTING [DOU8BLE PLATE ENTRY]		YES	No	No
PLATE/SHELL SUPPORT	WBALANCED			BALANCED
PLATE PRECURVING PRIOR TO ROLLING	NO	NO	YES	No
NUMBER OF ROLLER RESETTING OPERATIONS WITH PLATE UNCLAMPED	ROLLING ONLY	2	3	3
EVALIUTION OF TOLERANCES [A] EDGE SETTING [B] ROLLING ONLY		2 2	2 2	1.5 1
RANGE OF PLATE THICKNESS [CAMBSER DEPENDANT]	● FAIR	FAIR	FAIR	•GOOD
NUMBER OF DRIVEN ROLLERS AUXILLIARY DRIVE AVAILABLE	2 [LOWER] YES[UPPER]	2 [LOWER] YES [UPPER]	2 [LOWER] YES [UPPER]	2 [LOWERI ● YES [UPPER I
FRICTION MARKS ON PLATE SURFACE [THIN PLATE/LARGE DIAMETER]	NO (WITH 3 ROLLER DRIVE)	No	NO	NO (WITH 3 ROLLER DRIVE)
BENDING TIME COMPLETE	2 [EXCLUOING EDGE SETTING]	3	3	1.2 TO 1.4

[4] COMPARISON OF DIFFERENT 3-ROLLER SYSTEMS

TO MAKE A FAIR COMPARISON BETWEEN 3 & 4 ROLLER PLATE BENDING SYSTEMS, WE MUST FIRST SELECT THE BEST 3 ROLLER METHOD.

THE GEOMETRY OF THE PYRAMID SYSTEM [FIG. 1] WILL NOT BE SUITABLE FOR COMPLETED SHELL PRODUCTION WITHOUT ADDITIONAL OPERATIONS LIKE CUTTING-OFF FLAT ENDS, OR PRE-CURVING PLATE ENDS PRIOR TO ROUNDING OPERATION BY THE USE OF AUXILIARY EQUIPMENT.

THE ROLLER CONFIGURATIONS AS ILLUSTRATED IN FIGS. 1 TO IV ARE ALL SUITABLE FOR PLATE EDGE SETTING IN ADDITION TO ROUNDING OPERATIONS, HOWEVER, THOSE ILLUSTRATED UNDER FIG. II REQUIRE THE PLATE TO BE REMOVED, TURNED AND FED BACK INTO THE MACHINE FOR SETTING THE TRAILING EDGE.

WE OUTLINE BELOW A NUMBER OF THE MAIN ADVANTAGES OF THE TWICE INITIAL PINCH TYPE [IV] SYSTEM OVER THE OTHER 3ROLLER CONFIGURATIONS:

[]1 BACKED-UP LOWER ROLLERS ARE PRACTICALLY DEFLECTION FREE AND THEREFORE COMPENSATION AGAINST DEFLECTION HAS TO BE PROVIDED FOR TOP ROLLER ONLY.

[2] THE FEEDING OF THE PLATE IS ALWAYS HORIZONTAL AND AT A CONSTANT FIXED HEIGHT.

[]1 THE RELATION BETWEEN THE VERTICAL AXIS OF THE LOWER AND TOP ROLLER IS INFINITELY VARIABLE AND CAN BE SET TO THE OPTIMUM POSITION IN ACCORDANCE TO THE PLATE THICKNESS AND THE AVAILABLE PRESSURE.

[4] FROM THE SAFETY ASPECT, IT SHOULD BE NOTED, THAT THROUGHOUT THE ROLLING OPERATION THE WORKPIECE RESTS ON THE LOWER ROLLERS WHICH ARE ALWAYS AT THE SAME HEIGHT. THIS IS THE MOST STABLE ROLLER CONFIGURATION AMONG THE 3-ROLLER SYSTEMS.

IN CONCLUSION, TAKING INTO CONSIDERATION ALL ASPECTS OF SPEED, ACCURACY AND SAFETY, IT IS THE GENERAL CONSENSUS OF OPINION THAT THE BEST 3-ROLLER METHOD IS PROVIDED BY THE TWICE INITIAL PINCH TYPE

[5] DESCRIPTION OF SELECTED 3-ROLLER PLATE BENDING MACHINE

THE WORKING AND DESIGN REQUIREMENT OF THE 3-ROLLER PLATE BENDING MACHINE OF TWICE INITIAL PINCH TYPE CONSTRUCTION.

THE RECOMMENDED ROLLING PROCEDURE AND SEQUENCE OF OPERATION DIFFERS WITH EACH MANUFACTURER. HOWEVER, TWO MAIN METHODS SHOULD BE MENTIONED AS ALT. 1 & 2.

ALTERNATIVE 1:

1] TRAVERSE LOWER ROLLERS IN BLOCK TO FRONTEDGE SETTING POSITION. Offset

2] FEED PLATE BY CRANE, PREFERABLY BY FEEDING TABLE INTO FRONT EDGE SETTING POSITION WHEREBY FRONT EDGE OVERSHOOTS AXIS OF BOTTOM ROLLER.

3]. SET TOP ROLLER INTO BENDING POSITION.

4] EDGE SET THE PLATE BY DRIVING LOWER ROLLERS CLOCK-WISE. UPPER ROLLER, IF DRIVEN ANTI-CLOCKWISE, THUS COMPLETING FRONT EDGE SETTING.

5] RAISE TOP ROLLER AND TRAVERSE LOWER ROLLERS TO TRAILING EDGE SETTING LOCATION.

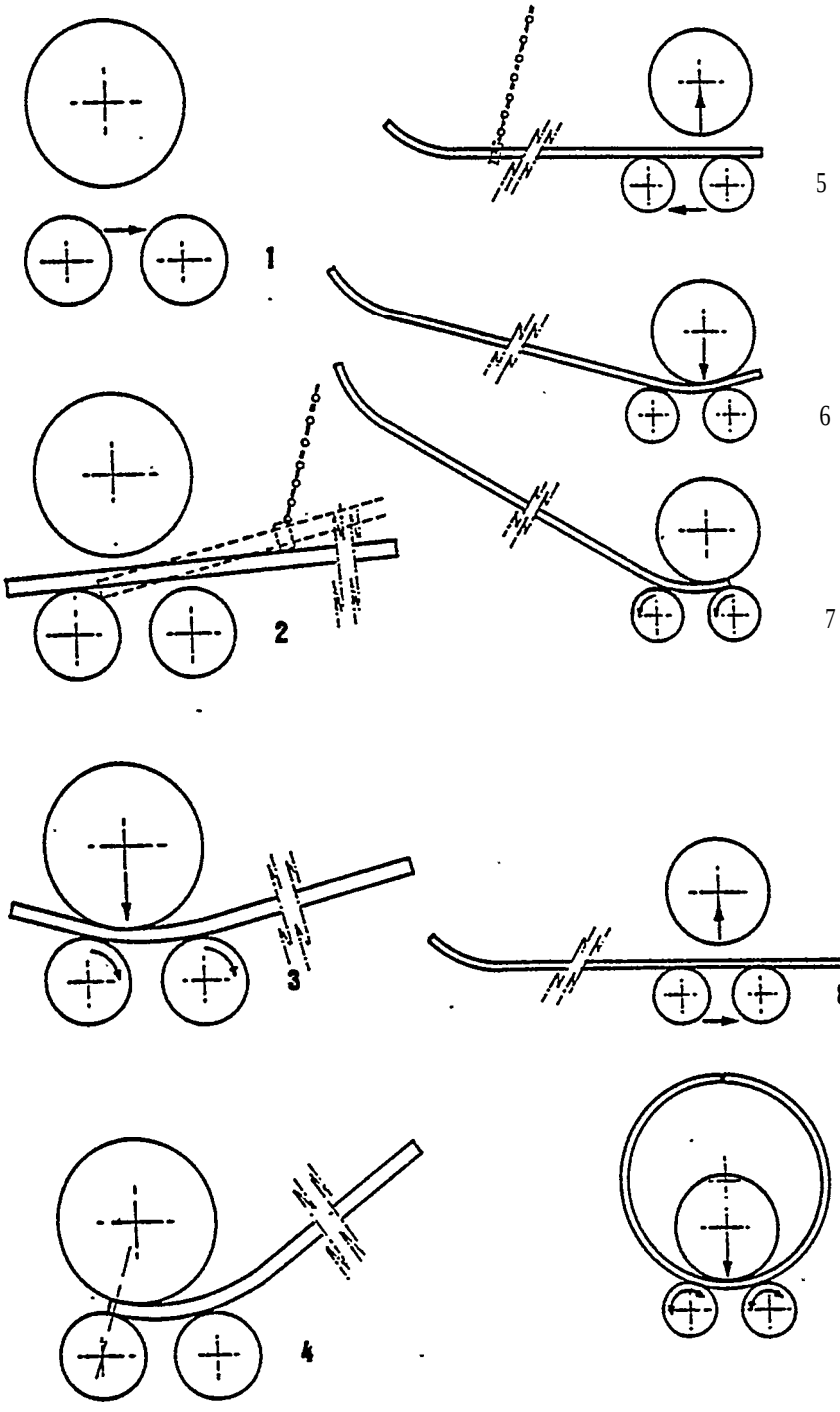
6] RE-POSITION PLATE FOR TRAILING EDGE SETTING BY ANTI-CLOCKWISE ROTATION OF LOWER ROLLERS.

7] CARRY OUT TRAILING EDGE SETTING IN THE SAME MANNER AS INDICATED FOR FRONT EDGE SETTING [PARAGRAPHS 3 & 4]

8] RAISE TOP ROLLER AND TRAVERSE BOTTOM ROLLERS TO PYRAMID FORMATION AND TRANSPORT ACCORDINGLY.

9] ROUND SHELL IN PYRAMID FORMATION.

ALTERNATIVE 1 :



ALTERNATIVE 2:

1] TRAVERSE LOWER ROLLERS IN BLOCK TO FRONT EDGE SETTING POSITION.

2] FEED PLATE BY CRANE, PREFERABLY BY FEEDING TABLE INTO FRONT EDGE SETTING POSITION WHEREBY FRONT EDGE OVERSHOOTS AXIS OF BOTTOM ROLLER.

3] SET TOP ROLLER INTO BENDING POSITION.

4] EDGE SET THE PLATE BY DRIVING LOWER ROLLERS CLOCK-WISE.. UPPER ROLLER, IF DRIVEN ANTI-CLOCKWISE, THUS COMPLETING FRONT EDGE SETTING.

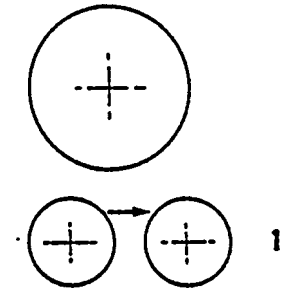
5] DRIVE THE LOWER ROLLERS ANTI-CLOCKWISE, THE TOP ROLLER, IF DRIVEN, CLOCKWISE AND ROLL THE PLATE UNTIL THE CENTRE OF GRAVITY OF THE PARTIALLY FORMED SHELL IS BETWEEN THE 2 LOWER ROLLERS.

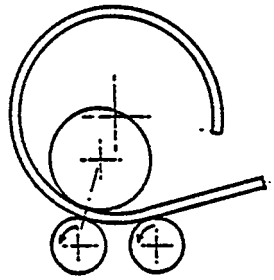
6] RAISE THE UPPER ROLLER, TRAVERSE THE LOWER ROLLERS IN BLOCK INTO TRAILING EDGE SETTING POSITION. DRIVE THE SHELL CLOCKWISE UNTIL THE FORMED PART OF THE PLATE RESTS ON BOTH LOWER ROLLERS.

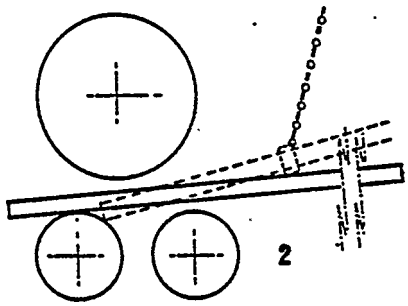
7] SET THE TOP ROLLER IN BENDING POSITION.

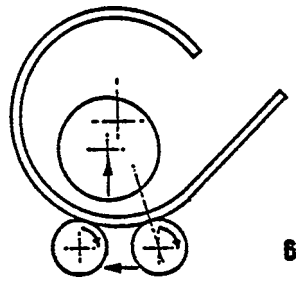
8] ROLL THE STILL UN-FORMED PLATED SECTION BY DRIVING THE LOWER ROLLERS ANTI-CLOCKWISE, AND THE TOP ROLLER CLOCKWISE, IT IS NOT DRIVEN.

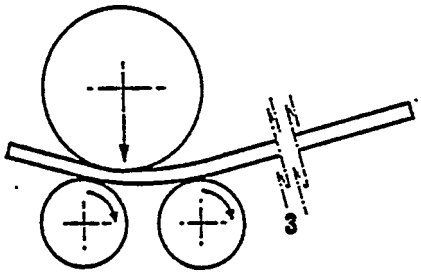
ALTERNATIVE 2:

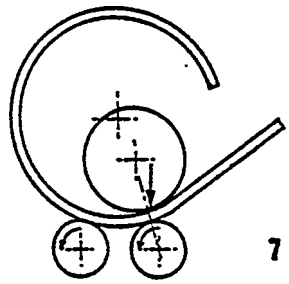


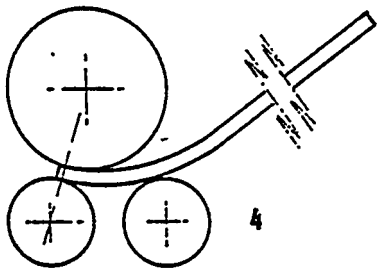


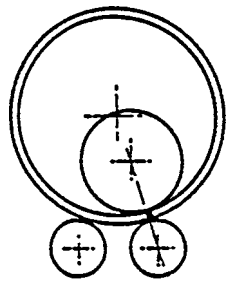












AN IMPORTANT ADVANTAGE OF THE SYSTEM IS THAT THE PLATE CAN BE FED HORIZONTALLY AT A CONSTANT HEIiGHT.

THE PLATE, THE SHELL OR THE PARTIALLY FORMED SHELL ALWAYS RESTS ON THE LOWER ROLLERS WHICH ARE AS PREVIOUSLY MENTIONED, AT A CONSTANT HEIGHT. THIS IS PARTICULARLY IMPORTANT FOR HOT BENDING DUE TO THE DANGER OF UNCONTROLLED MOVEMENT OF LARGE, HOT WORKPIECES.

THE SIMPLE OPERATIONS A FURTHER POINT IN FAVOUR OF THIS SYSTEM, AS THE BENDING RADIUS IS DETERMINED SOLELY BY THE HEIGHT POSITIONING OF THE UPPER ROLLER. [IN OTHER 3-ROLLER SYSTEMS, IT DEPENDS ON 2 ROLLER ADJUSTMENT].

THE LOWER ROLLERS CAN TRAVERSE AT ANY TIME INTO THE OPTIMUM PLATE EDGE SETTING POSITION AND REGARD-LESS OF WHETHER THIS IS CARRIED OUT BEFORE OR AFTER THE ROUNDING OPERATION.

THE MACHINE IS SUITABLE FOR RE-ROLLING [CALIBRATING] OF LONGITUDINALLY SEAM WELDED SHELLS BUT ONLY IN THE CASE WHERE WELDED EDGES ARE PEAKED INWARDS. AND IN OTHER WORDS, NOT SUITABLE IN THE CASE WHERE WELDED EDGES ARE PEAKED OUTWARDS. CONE BENDING OPERATION CAN BE PERFORMED IN A PRESS BRAKE MANNER, WHEREBY, THE CONE BLANK WITH MARKED BENDING LINES, IS POSITIONED OVER THE BOTTOM ROLLERS AND UNDER THE TOP ROLLER. THE TOP ROLLER TILTED AND USED AS A PRESS DIE.

DESIGN REQUIREMENT :

1 : HYDRAULIC SYSTEM

[a] FOR TOP ROLLER POSITIONING WITH FULL OVERLOAD PROTECTION.

[b] FOR CROSS TRAVERSE OF BOTTOM ROLLER IN BLOCK

[c] FOR INDEPENDENT HYDRO-MOTOR DRIVE TO PROVIDE AUTOMATIC LINEAR SPEED COMPENSATION BETWEEN TOP AND BOTTOM ROLLERS, THUS ACHIEVING THE CORRECT INTERNAL AND EXTERNAL CIRCUMFERENTIAL SPEED ACCORDING TO PLATE THICKNESS OF THE SHELL TO BE ROLLED. FURTHER MORE, TO AVOID SLIPPAGE, SKIDDING, SURFACE SCORING OR SPIRALLING.

2 : POSITIVE TOP ROLLER POSITIONING THROUGH ROBUST SLIDE AND SLIDE GUIDING SYSTEM.

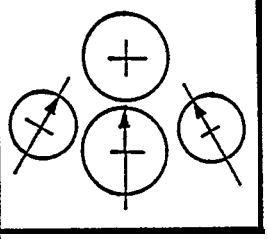
3 : THE CROSS TRAVERSING LOWER ROLLER BLOCK SHOULD BE EXCEPTIONALLY MASSIVE, SET IN ROBUST GUIDING SYSTEM WITH CONSTANT LUBRICATION AND EQUIPPED WITH HIGHLY EFFICIENT LOCK MECHANISM TO MAINTAIN THE SET POSITION.

4 : ANTI-FRICTION BEARINGS TO PROVIDE EFFICIENCY IN POWER CONSUMPTION AND ELIMINATE COOLING PROBLEMS.

5 : CENTRALIZED PUSH BUTTON AND DIAL CONTROLS ON PIVOTED PANEL TO ENABLE ONE OPERATOR TO WORK FROM BOTH SIDES OF THE MACHINE.

6 : SUITABLE DESIGN TO ACCOMMODATE PLATE FEEDING AND SHELL DISCHARGING UNITS, THE LATTER CAUSES CONSIDERABLE PROBLEMS.

[6] ROLLER CONFIGURATION -4 ROLLER SYSTEM

TWIN INITIAL PINCH 4-ROLLER [V]			

ROLLER CONFIGURATION :4 ROLLER TWIN INITIAL PINCH [v]

THE. MACHINE IS-CONSTRUCTED WITH 4 ROLLERS : ONE TOP ROLLER ONE BOTTOM ROLLER TWO SIDE ROLLERS THE ONE TOP ROLLER IS IN THE FIXED POSITION WITHOUT ADJUSTABILITY, THE ONE BOTTOM ROLLER VERTICALLY AND THE TWO SIDE ROLLERS WITH AN ANGLE TOWARDS THE TOP ROLLER, ARE ADJUSTABLE. THE ADJUSTMENT CAN BE CARRIED OUT INDEPENDENTLY OF EACH OTHER.

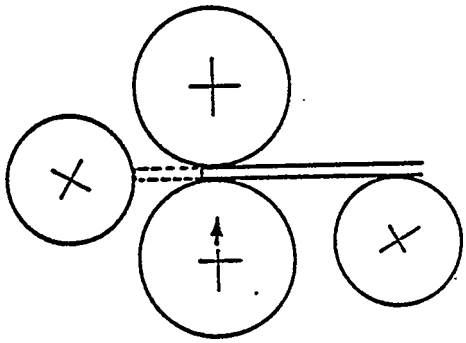
ROLLER DRIVE BASIC DESIGN TOP ROLLER.

ADVANCED DESIGN TOP AND BOTTOM ROLLERS WITH LINEAR SPEED COMPENSATION.

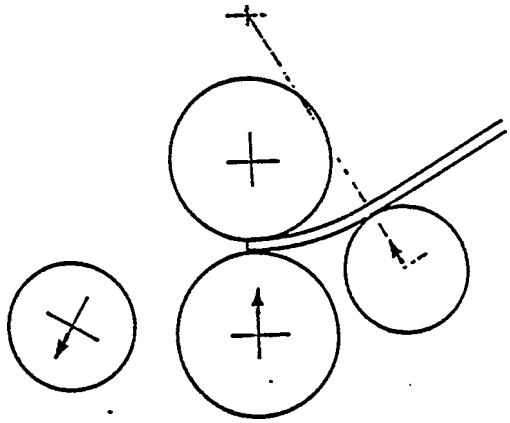
PLATE EDGES ARE SET IN THE MACHINE WITHIN THE OPERATING CYCLE, ,LE., SET IN-GOING EDGE, CARRY OUT ROUNDING AND SET TRAILING EDGE IN ONE CONTINUOUS OPERATION. ALTERNATIVELY SET BOTH PLATE EDGES PRIOR TO ROUNDING OPERATION AND CARRY OUT ROUNDING ON COMPLETION OF EDGE CURVING. NOTE: TOP AND BOTTOM ROLLER CLAMPS PLATE THROUGHOUT THE WHOLE PRODUCTION CYCLE AND PROVIDES COMPENSATED INTERNAL AND EXTERNAL LINEAR SPEED IN ACCORDANCE TO THE REQUIREMENT OF THE THICKNESS OF PLATE TO BE BENT.

THE MACHINE WITH TOP AND BOTTOM ROLLER DRIVE AT A COMPENSATED LINEAR SPEED, WILL PRODUCE A FIRST CLASS SHELL WITH QUALITY EDGE PREPARATION WITHIN THE CAPACITY OF THE MACHINE

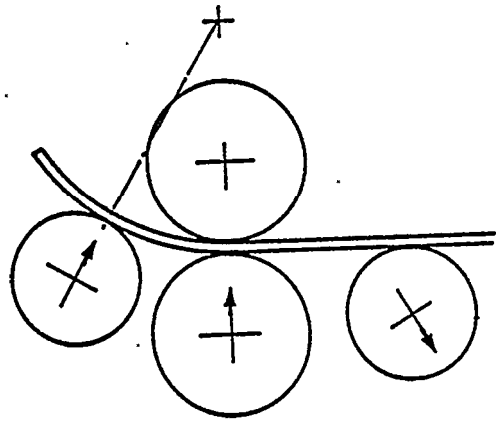
COST OF EQUIPMENT - HIGH BRACKET



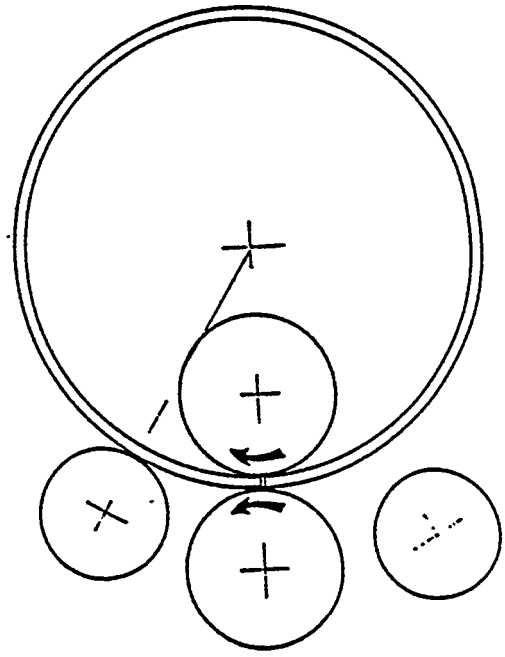
[1] ALIGN PLATE AGAINST EXIT SIDE ROLLER & REPOSITION FOR EDGE-SETTING [PLATE REMAINS CLAMPSD BETWEEN UPPER & LOWER ROLLERS~



[21 LOWER EXIT SIDE ROLLER, RAISE ENTRY StDE ROLLER TO EDGE-SST LEADING PLATE



B] LOWER ENTRY SIDE ROLLER & RAISE EXIT. SIDE ROLLER [PLATE REMAINS CLAMPED FJ::WJ::% UPPER & LOWER



[41 CONTINUE ROLLING REMAIN-DER OF PLATE, TRAILING EOCE BEING AUTOMAmCALLY SET.

[7] DESCRIPTION OF 4-ROLLER PLATE BENDING MACHINE

THE WORKING AND DESIGN REQUIREMENT OF 4 ROLLER PLATE BENDING MACHINES OF TWIN INITIAL PINCH TYPE CONSTRUCTION.

A: WORKING OF MACHINE :

1 : PLATES ARE AUTOMATICALLY ALIGNED BY SIMPLY DRIVING UNDER LIGHT PRESSURE BETWEEN TOP AND LOWER ROLLERS AGAINST EXIT SIDE ROLLER SET TO END STOP POSITION, ON WHICH FRONT PLATE EDGE AUTOMATICALLY POSITIONS ITSELF. A FEEDING TABLE WILL SPEED UP TO OPERATION.

2: ON COMPLETION OF PLATE ALIGNMENT AND BY PUSH BUTTON CONTROL, PLATE WILL BE DRIVEN UNDER INCREASED PRESSURE BETWEEN TOP AND LOWER ROLLER TO FRONT EDGE-SETTING POSITION. NC OR CNC, IN ADDITION TO LIGHT BEAM PROTECTION DEVICE, CAN BE INCORPORATED FOR EFFORTLESS, SAFE OPERATION.

3: DUE TO THE FACT THAT THREE OF ITS FOUR ROLLERS ARE TILTABLE AND THAT THE TOP AND BOTTOM ROLLERS ARE DRIVEN, THE MACHINE IS PARTICULARLY SUITABLE FOR CONE ROLLING. CONTRARY TO TRADITIONAL MACHINE DESIGN, TOP AND BOTTOM ROLLERS ARE SET AT AN ANGLE TO DRIVE CONE BLANK AT THE LARGE END, WHILE THE TWO SIDE ROLLERS ARE SET AT AN OPPOSITE ANGLE TO GLIDE ON THE SMALL END OF THE BLANK WHICH IS BEING GUIDED BY A SPECIAL, DEVICE.

3 Contd.

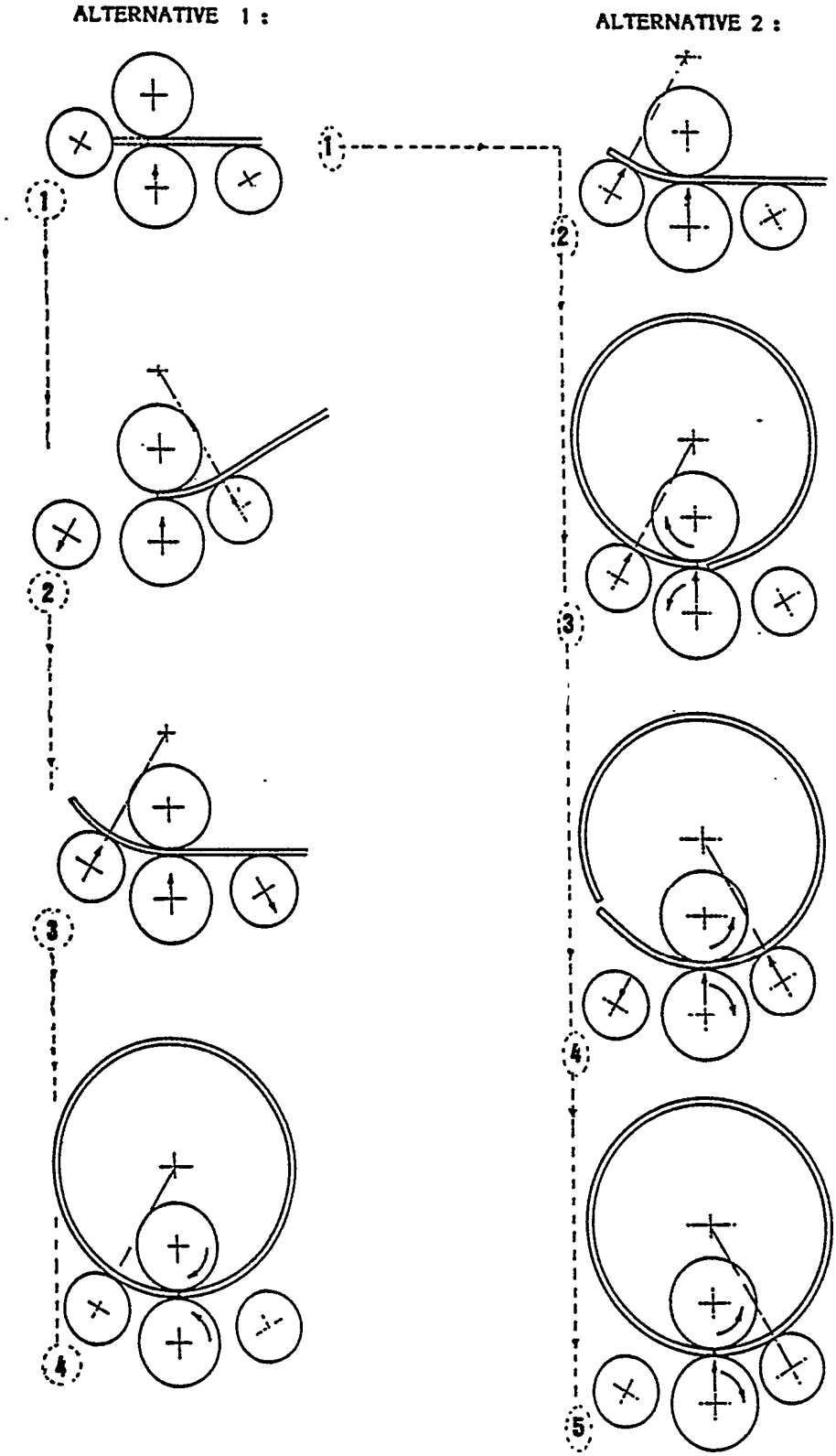
CONE ROLLING ON A 4-ROLLER MACHINE IS A CONTINUOUS OPERATION FROM START TO FINISH, INCLUSIVE OF EDGE. SETTING. THERE IS NO RE-POSITIONING OF THE BLANK, AS IS USUAL ON A 3-ROLLER MACHINE BEING USED AS A COMBINED PRESS BRAKE AND ROLLING MACHINE, HOWEVER, EDGE DRESSING OF SMALL CONE END IS REQUIRED.

4 : MACHINE WILL SET THE LEADING EDGE, ROLL AND SET THE TRAILING EDGE OF THE PLATE IN ONE CONTINUOUS OPERATION.

5 : THE PLATE REMAINS FIRMLY CLAMPED BETWEEN TOP AND BOTTOM ROLLERS THROUGHOUT THE ENTIRE ROLLING AND EDGE-SETTING OPERATION, RE-POSITIONING OF THE PLATE, OR PARTIALLY FORMED SHELL IS ELIMINATED AND THEREFORE OPERATOR SKILL REQUIREMENT IS REDUCED.

6 : ON COMPLETION OF ROLLING, THE TWO EDGES OF THE SHELL TO BE TACK WELDED CAN BE BROUGHT CORRECTLY TOGETHER BY APPLYING PRESSURE WITH THE TWO SIDE ROLLERS, WHILST THE SHELL IS FIRMLY CLAMPED BETWEEN THE TOP AND BOTTOM ROLLERS. ANY SLIGHT SPIRALLING WHICH MAY HAVE OCCURED DURING ROLLING CAN BE CORRECTED BY TILTING EITHER OR BOTH SIDE ROLLERS AS REQUIRED.

7 : WITHIN THE EDGE-SETTING CAPACITY OF THE MACHINE, LONGITUDINALLY WELDED SHELLS CAN EASILY BE RE-ROLLED, WHETHER WELDED EDGES ARE PEAKED INWARDS OR OUT-WARDS. THE 4 ROLLER ARRANGEMENT PROVIDES FOR SHELL CALIBRATION TO CLOSE TOLERANCES.



ALTERNATIVE ROLLING WITH A 4-ROLLER SYSTEM

B : DESIGN REQUIREMENT:

8 : HYDRAULIC SYSTEM:

A] SYNCHRONISED ROLLER POSITIONING FOR PLATE CLAMPING, SETTING AND ROLLING UNDER FULL OVERLOAD PROTECTION

B] FOR INDEPENDENT HYDRO-MOTOR DRIVE TO PROVIDE AUTOMATIC LINEAR SPEED COMPENSATION BETWEEN TOP AND BOTTOM ROLLER THUS ACHIEVING THE CORRECT INTERNAL AND EXTERNAL CIRCUMFERENTIAL SPEED ACCORDING TO PLATE THICKNESS OF THE SHELL TO BE ROLLED. FURTHERMORE TO AVOID SLIPPAGE, SKIDDING SURFACE SCORING OR SPIRALING.

9 : POSITIVE ROLLER POSITIONING THROUGH EXTENDED SLIDE LENGTH AND CORRESPONDING GUIDING SYSTEM TO ACHIEVE AND MAINTAIN ACCURACY AND UNIFORMITY IN PLATE ROLLING AND SHELL CALIBRATION TO CLOSE TOLERANCE AFTER WELDING.

10: ANTI-FRICTION BEARINGS TO PROVIDE EFFICIENCY IN POWER CONSUMPTION AND ELIMINATE COLLING PROBLEMS.

11 : CENTRALIZED PUSH-BUTTON AND DIAL CONTROLS ON PIVOTTED PANEL TO ENABLE ONE OPERATOR TO WORK FROM BOTH SIDES OF THE MACHINE.

12: EASY ADAPTIBILITY OF AUXILLIARY SUPPORT ELEMENTS, PURPOSE BUILT CRANES, PLATE FEEDING AND SHELL DISCHARGING UNITS.

BATCH PRODUCTION TIME : COMPARISON

SHELL TO BE ROLLED : 3000 X 75MM TO AN INTERNAL DIA. OF 1600MM .

	4-ROLLER TWIN INTIAL PINCH	3-ROLLER TWICE INITIAL PINCH
[a] Plate Loading and Aligning of Leading Edge.	2.5	8.0
[b] Plate Positioning for Leading Edge Setting.	1.0	1.0
[cl Leading Edge Setting	5.0	5.0
[d] Entry Side Roller Lowered	1.5	
[e] Exit Side Roller Raised	1.5	
[f] Top Roller Raising		0.5
[g] Adjusting Lower Rollers in block for Trailing Edge Setting.		2.0
[h] Repositioning of plate		3.5
[i] Plate Rounding including Trailing Edge Setting.	12.0	
[j] Plate Positioned for Trailing Edge Setting		0.5
[k] Trailing Edge Setting		5.0
[I] Raising Top Roller		0.5
[m] Adjusting Lower Rollers to Symmetrical Configuration for Rounding		1.0
[nl Top Roller Lowered		1.0
[0] Bending Operation		13.0
[p] Front Bearing, remove rolled Close Front Bearing ready for next plate.	2.5	3.0
TOTAL	26.0	44.0
OUTPUT RATIO :	100%	59%

ABOVE DATA COMPILED BY MANUFACTURER BUILDING BOTH SYSTEMS, AND CONTROLLED UNDER ACTUAL WORKING CONDITIONS IN USER'S SHOP.

[8] COMPARISON OF 3 AND 4 ROLLER MACHINES AND COMPARATIVE ANALYSIS OF PAY-BACK BETWEEN 3 & 4 ROLLER SYSTEMS

COMPARISON BETWEEN 3 & 4 ROLLER MACHINES OF HYDRO-MECHANICAL CONSTRUCTION - TECHNICAL ADVANTAGES - COST AND PAY-BACK :

THE CHARTS ON PAGES 58 AND 59 TABULATE THE TECHNICAL MERITS AND EVALUATION OF EACH SYSTEM OVER THE OTHER.

TO CARRY OUT A COMPARISON FOR PAY-BACK CALCULATION IT SHOULD BE NOTED THAT A 3-ROLLER OR 4-ROLLER MACHINE OF HYDRO-MECHANICAL ADVANCED DESIGN SHOULD BE TAKEN AS AN IDENTICAL CAPITAL OUTLAY, WITH AN IDENTICAL MAINTENANCE AND REPAIR COST. THEREFORE, ALL THINGS BEING EQUAL, THE DECIDING FACTORS ARE AS FOLLOWS :

OUTPUT FACTOR :
3 ROLLER 0.6
4 ROLLER 1.0

QUALITY FACTOR:
3 ROLLER 1.0
4 ROLLER 1.0

IN GENERAL, A 10 YEARS THEORETICAL PAY-BACK CALCULATED FOR A 3-ROLLER WILL BE REDUCED TO 6 YEARS FOR A 4-ROLLER SYSTEM AT IDENTICAL UTILISATION. HOWEVER, IT MUST BE EMPHASISED THAT THE ULTIMATE SELECTION BETWEEN THE TWO SYSTEMS SHOULD DEPEND ON THE EMPLOYMENT OF SUCH SYSTEM. IN OTHER WORDS, THE PRODUCTION PROGRAMME ITSELF SHOULD BE THE SOLE FACTOR WHEN MAKING THE DECISION IN MACHINE SELECTION. IN THIS RESPECT IT WOULD BE ADVANTAGEOUS TO OBSERVE THE FOLLOWING :

.

WHERE THE USE OF A 4-ROLLER TWIN INTITIAL PINCH TYPE IS PREFERENTIAL:

1 : IN GENERAL FOR MASS PRODUCTION OF SMALL TO LARGE DIAMETER SHELLS, OF A GOOD QUALITY AT A FAST PRODUCTION RATE DUE TO:

a] UNITERUPTED RE-POSITIONING FREE SHELL ROLLING WITH THE SECURITY OF CONTINUOUS PLATE CLAMPING.

b] ADAPTABILITY FOR EASY PLATE FEEDING, ALIGNING AND SHELL DISCHARGING METHOD [MATERIAL HANDLING]

C] VERSATILE SHELL RE-ROLLING FACILITY WHERE HIGH ACCURACY IS REQUIRED.

2 : WHERE MANUFACTURING REQUIREMENT CALLS FOR TACK WELDING OPERATION PRIOR TO DISCHARGE OF ROLLED SHELL, AS THE SIDE ROLLERS ARE EASILY ADJUSTABLE//TILTABLE, AND THEREFORE THE MARRYING OPERATION OF OPEN EDGES CAN BE PERFORMED WITHOUT DIFFICULTY.

3 : WHERE CONE BENDING FORMS A LARGE PROPORTION OF THE PRODUCTION, PROVIDING TIME IS ALLOWED FOR EDGE DRESSING OF SMALL CONE-END.

4 : THE ONLY METHOD FOR THE AUTOMATIC PRODUCTION OF CYLINDRICAL AND NON-CYLINDRICAL SHELLS WITH VARIABLE INTERNAL RADII [OVAL TANKS, MAXI TANKS AND SIMILAR lTEMS] :

IN ADDITION TO THE ABOVE, IT SHOULD BE NOTED THAT WHILE THIS MACHINE IS SUITABLE FOR EXTRA LARGE DIAMETER SEGMENTED SHELL ROLLING, IT SHOULD BE SELECTED ONLY IN CASES WHERE SMALL AND MEDIUM DIAMETER ROLLING IS ON EQUAL IMPORTANCE WITHIN THE PRODUCTION PROGRAMME AND THE PLATE THICKNESS DOES NOT EXCEED 3" AT FULL WIDTH ROLLING.

IT IS INTERESTING TO NOTE, THAT DUE TO THE SIMPLE PRODUCTION SEQUENCE, A HIGHLY SKILLED OPERATOR IS NOT ESSENTIAL AND THEREFORE ANY CHANGE OF PERSONNEL DOES NOT PRESENT A PROBLEM.

WHERE THE USE OF 3-ROLLER TWICE INITIAL PINCH TYPE IS PREFERENTIAL

1 : PRECISION ONE-OFF SHELL ROLLING WITH CONTINUOUS HORIZONTAL SUPPORT FACILITY.

2 : FOR HOT ROLLING, REGARDLESS OF PLATE THICKNESS OR PLATE WIDTH.

3 : EXTRA LARGE AND LARGE DIAMETER SEGMENTED SHELL ROLLING.

4 : CONE BENDING WHERE DRESSING OPERATION OF SMALL CONE END IS NOT ACCEPTABLE.

5 : EDGE SETTING, WITH MINIMUM FLAT END RELATIVE TO THE AVAILABLE CAPACITY OF THE MACHINE, OR WITH LONGER FLAT END AND INCREASED PLATE THICKNESS ABOVE STATED CAPACITY OF THE MACHINE. IN OTHER WORDS, MANIPULATE THE VARIABLE GEOMETRY OF THE ROLLER CONFIGURATION.

CHART II

COMPARISON BETWEEN 3 & 4 ROLLER MACHINES

TYPE	TWICE INITIAL PINCH		TWIN INITIAL PINCH	
	ADVANTAGE	DISADVANTAGE	4DVANTAGE	DISADVANTAGE
GENERAL				
FEEDING OF PLATE	CONSTANT HEIGHT		CONSTANT HEIGHT OPENDENT ON PLATE THICKNESS	
ALIGNMENT OF PLATE		FEEDING TABLE WITH LATERAL GUIDES REQUIRED.	SEMI-AUTOMATIC AGAINST FAR END SIDE ROLLER.	FEEDING TABLE ADVANTAGEOUS
POSITION OF PLATE FOR EDGE-SETTING		OPERATOR SKILL REQUIRED	S PLATE IS CLAMPED BETWEEN UPPER/LOWER ROLLERS - NO OPERATOR SKILL REQUIRED	
EDGE-SETTING OF LEADING EDGE	WITHOUT DIFFICULTIES		NC OF ROLLER ROTATION TO ELIMINATE DISADVANTAGES	D ACHIEVE THE ABSOLUTE MINIMUM FLAT END GREAT PRECAUTION REQUIRED
EDGE-SETTING AT SMALL DIA. BENDING.	HORIZONTAL PLATE POSITION SLIGHTLY CHANGED [MINIMAL INCLINATION]			LATE CAN BE LIFTEll ALMOST VERTICALLY
ROLLER SETTING [RE-SETTING]				
[A] CHANGE FROM LEADING EDGE TO TRAILING EDGE SETTING		RELEASE TOP ROLLER CLAMPING PRESSURE RE-POSITION BOTTOM ROLLERS IN BLOCK & PLATE ON BOTTOM ROLLERS TO TRAILING. EDGE SETTING POSITION.	CONTINUOUS OPERATION FROM EDGE SETTING [LEADING] THROUGH ROUNDING TO EDGE SETTING [TRAILING] WITHOUT RE-PORTIONING PLATE OR RELEASING CLAMPING PRESSURE BETWEEN TOP & BOTTOM ROLLERS	
[B] CHANGE FROM ROLLING TO TRAILING EDGE SETTING TO ROLLING		RELEASE TOP ROLLER CLAMPING PRESSURE RE-POSITION BOTTOM ROLLERS IN BLOCK & PLATE TO ROUNDING POSITION & COMPLETE ROLLING.		
LENGTH OF 'FLAT' I-RON/I TRAILINGI	MINIMAL - WITH MINIMUM OPERATOR SKILL		SHORT-WITH OPERATOR SKILL OR NC	
WORKING CAPABILITY				
3 ROLLER M/C OVER 4 ROLLER	NONE			
4 ROLLER M/C OVER 3 ROLLER			. COPY ROLLING & OTHER CONCAVE SHAPES . PROGRAMMABLE FOR AUTOMATIC PRODUCTION	
CALIBRATION		NEEDS SKILL	. LONGITUDINAL WELD FLAT EDGE CORR-ECTION - CALIBRATION OF PEAR SHAPED FLAT EDGE	
TACKING OPERATION		NEEDS SKILL	- CLOSE & TACK WELL TUBULAR MACHINE	

ABOVE DATA COMPILED BY MANUFACTURER BUILDING BOTH SYSTEMS, AND CONTROLLED UNDER ACTUAL WORKING CONDITIONS IN USER'S SHOP.

CHART I I IContd.]

T Y P E	TWICE INITIAL PINCH		TWIN INITIAL PINCH	
	ADVANTAGE	DISADVANTAGE	ADVANTAGE	DISADVANTAGE
CONE BENDING PREPARATION		MARKING BENDING LINES		
OPERATION		CONSECUTIVE PRESSING	ROLLING OPERATION	
CIRC-WELDING EDGE PREPARATION [SMALL END]	GOOD			REQUIRES DRESSING
[LARGE ENDI	GOOD		GOOD	
RELATIVE BENDING TIMES		1.5	I	
IDAMETER: SMALL		3 x	I	
MEDIUM		2 x	1 .	
LARGE		1.2- 1.5 x	1	
PLATE: THIN		2 x	I	
THICK		1.2- 1.5 x	I	
SEGMENT ROLLING S,YMMETRIC WITHOUT TTING]	I			1.2- 1.5 x
FLATND WHEN SYNNETRICALSEGMENT ROLLING	RELATIVELY SHORT DUE TO CLOSE POSITION OF SUPPORTED LOWER ROLLERS IN BLOCK		IN CASE BACKED UP SIDE ROLLERS- FLATE BECOMES SHORT	FAIRLY LONG DUE TO DIAMETER & DISTANCE OF 2 UNSUPPORTED SIDE ROLLERS
	COMPARISON FIG. 1			COMPARISON FIG. 1 - 1.5
CONSTRUCTION FEATUREs				
STANDARD DRIVE	UPPER ROLLER	2 LOWER ROLLERS	UPPER/LOWER ROLLERS	
AUXILIARY DRIVE		ADDITIONAL COST	NET NECESSARY	
DRIVING QUALITY:		POSSIBLE PROBLEMS	)	
DIAMETER: LARGE		DUE TO LOW PRESSURE	)	
		REQUIREMENT	)	
SMALL	NO DIFFICULTY		) NO :fLFICULTIES	
PLATE THICKNESS: THIN		POSSIBLE PROBLEMS		
THICK	NO DIFFICULTY		)	
CAMBERING OF ROLLER				
LOWER ROLLERS	MINIMAL CAMBERING IF ANY [SUPPORTED IN BLOCK]			
UPPER ROLLER		CAMBERED	NO CAMBERING IF PRE-STRESSED	CAMBERED [STANDARD]
CONSTRUCTION PARTS GREATER THAN 50/60 TONS IN WEIGHT	POSSIBLE			PROBLEMATIC IN CERTAIN CASES.
QUALITY OF PRODUCT	1.0		I .0	
PAYBACK FACTOR	0.59		1 . 0 0	

ABOVE DATA COMPILED BY MANUFACTURER BUILDING BOTH SYSTEMS AND CONTROLLED UNDER ACTUAL WORKING CONDITIONS IN USER'S SHOP.

[9] CASE STUDY

[1] BABCOCK POWER LTD.

Mr. J. JOHNSTON
ES Overseas Liaison

MAJORITY OF PRODUCTION IS FOR THE POWER GENERATING INDUSTRIES

IN 1963 THEY INSTALLED A 3-ROLLER TWICE INITIAL PINCH TYPE MACHINE WITH A NOMINAL COLD ROLLING CAPACITY OF 4000 X 90 MM, WITH A FACILITY FOR HOT ROLLING.

THE MACHINE IS EQUIPPED WITH IN AND OUT FEED UNITS, INCORPORATING A PLATE SQUARING MECHANISM ON THE IN-FEEDING SIDE.

ONE OPERATOR WITH AN ASSISTANT ARE EMPLOYED.

DEPENDENT ON OPERATOR SKILL, THE NOMINAL FLAT END IS 1½ x PLATE THICKNESS AT MAXIMUM CAPACITY UTILIZATION.

SYMETRIC [PYRAMID] ROLLING INCREASED THE MACHINE CAPACITY BY APPROXIMATELY 10% WHEREAS HOT ROLLING AT 1050° C DOUBLES THE CAPACITY. .

TYPICAL PRODUCTION IS SHELLS FOR 660 MW POWER STATION BOILERS. HOT ROLLING PRODUCTION TIME FOR A SHELL OF 114 MM WALL THICKNESS, 1800 MM IN DIAMETER, 25 - 30 MINUTES, WHILE A SHELL OF 160 MM WALL THICKNESS, 2210 MM IN DIAMETER 1S 45 - 50 MINUTES. COLD ROLLING PRODUCTION TIME FOR A SHELL OF 76 MM WALL THICKNESS, 1600 MM IN DIAMETER 40-45 MINUTES.

MACHINE UTILIZED 50% OF THE TIME. MAINTENANCE COST IS LOW, ONE MAJOR OVERHAUL IN 7 YEARS. AT THE TIME OF INSTALLATION THE MACHINE COST AROUND £150,000.00 WHICH WAS DEPRECIATED OVER A PERIOD OF 15 YEARS.

USER WOULD PREFER HYDRAULIC DRIVE AND ROLLER BEARINGS. TIME TO CHANGE TOP ROLLER IS SHOMEWHAT LENGTHY TAKING AROUND 4-5 HOURS.

[9] CASE STUDY

[2] HIGHLAND FABRICATORS LTD.

Mr. J. Mitchell
Pipe Mill
Superintendent.

MAJOR FABRICTORS OF OFFSHORE PLATFORMS.

IN 1974 THEY INSTALLED A COMPLIMENTARY RANGE OF 3-ROLLER INITIAL PINCH TYPE MACHINES [3 IN NUMBER] TO COVER THEIR OVER-ALL ROLLING REQUIREMENT.

THE MACHINES ARE EQUIPPED WITH 2 ROLLER DRIVE [LOWER ROLLERS ONLY] AND AN ELECTRO-MECHANICAL ROLLER POSITIONING;

EACH MACHINE IS PROVIDED WITH ONE JIB CRANE FOR MATERIAL HANDLING AND SERVED BY AN OPERATOR AND A HELPER.

MAJORITY OF WORK IS CARRIED OUT ON THE MACHINE WITH CAPACITY OF 4000 X 63.5 MM. UP TO 50 MM IN PLATE THICKNESS, WEDGES ARE USED FOR CONSECUTIVE EDGE SETTING. ABOVE 50 MM PLATE THICKNESS, EXCESS FLAT IS FLAME CUT.

TIME TO ROLL AN INDIVIDUAL CAN 3000 MM LONG, 63.5 MM IN WALL THICKNESS AND 2000 MM IN DIAMETER, EXCLUSIVE OF EDGE SETTING, TAKE 35 - 40 MINUTES, PLUS 10 MINUTES FOR EDGE SETTING BY WEDGING AND AN EXTRA 10 MINUTES FOR TACKING.

- RE-ROLLING FOLLOWING LONGITUDINAL SEAM WELDING REQUIRED IN MOST CASES. BARELLING TOLERANCE MUST NOT EXCEED 3 MM OVER 3000 MM ROLLING LENGTH.

SPIRALLING OCCURS WHICH CAN BE CORRECTED BY FLAME CUTTING ONLY. THERE IS ALSO ANOTHER PROBLEM OF PLATE SURFACE MARKING DUE TO WEDGING OPERATION.

DURING CONTRACT TIME, THE MACHINES ARE FULLY UTILIZED WITH VERY LITTLE DOWN TIME. HOWEVER, FOR MAINTENANCE, QUITE SOME TIME IS REQUIRED. USUALLY 1 DAY PER MONTH IN ADDITION TO NORMAL DAILY MAINTENANCE.

AT THE TIME OF INSTALLATION, THE MACHINE COST AROUND S200,000.00 AND DEPRECIATION IS PLANNED OVER A PERIOD OF 15 YEARS.

[9] CASE STUDY.

[3] HUMBERSIDE FABRICATORS LTD.

Mr. T. ALLEN
Managing Director

SMALL PRIVATELY OWNED COMPANY ACTING AS SUB-CONTRACTOR TO THE OFFSHORE INDUSTRY.

THEIR RANGE OF EQUIPMENT IS A 4-ROLiER PLATE BENDING MACHINE, OF 'TWIN INITIAL. PINCH TYPE CONSTRUCTION WITH A NOMINAL CAPACITY OF 3000 X 90 MM OPERATED BY ONE MAN PLUS A WELDER FOR PRE-HEATING AND TACK WELDING OF SHELLS. RANGE OF PRODUCTION IS 10 FEET LONG SHELL - 1 TO 2½ INCH WALL THICKNESS AND 36 tO 78 INCHES IN DIAMETER. FLOOR TO FLOOR TIME, INCLUDING TACK WELDING FOR DIAMETERS BELOW 60 INCHES IS APPROXIMATELY 30 MINUTES OF WHICH ROLLING TIME IS IN THE RANGE OF 10 - 15 MINUTES. ALL TIMES RELATE TO LARGE BATCH PRODUCTION.

THE TIGHT TOLERANCES WORKED TO, SOMETIMES NECESSITATES THAT EXCESS FLAT ENDS ARE CUT-OFF AND FOLLOWING LONGITUDINAL WELDING AND SHELLS ARE RE-ROLLED. RE-ROLLING WHERE NECESSARY TAKES APPROXIMATELY 20 MINUTES [FLOOR TO FLOOR].

A USEFUL FEATURE OF THE 4-ROLLER MACHINE IS ITS ABILITY TO BUTT UP JOINTS FOR TACK WELDING, BY USE OF THE SIDE ROLLERS, IN ADDITION TO THE ACCURATE RE-ROLLING FACILITY.

THE MACHINE WAS PURCHASED IN 1973 AT AN APPROXIMATE COST OF E250,000.00 - DEPRECIATION FIGURES NOT AVAILABLE.

[9] CASE STUDY

. [4] NEI INTERNATIONAL COMBUSTION LTD

Mr. B.J. HEITZMAN
Manager : Manufacturing Engineering.

IN THE LATE 60's, THIS COMPANY INSTALLED A 3-ROLLER HYDRO-MECHANICAL. PINCH PYRAMID MACHINE WITH A CAPACITY OF 11 FEET X 2¼ INCH FOR COLD ROLLING, 2 INCH FOR EDGE SETTING AND 100% EXCESS FOR HOT WORKING.

MAJORITY AND WORK IS FOR THE POWER GENERATING INDUSTRY TYPICAL PRODUCT IS BOILER DRUMS, 10 FEET IN LENGTH, BETWEEN 2 AND 5 INCHES IN WALL THICKNESS AND BETWEEN 36 AND 72 INCHES IN DIAMETER. FLOOR TO FLOOR TIME FOR SHELL 10' x 2" ROLLED TO 48 INCH DIAMETER IS 4 HOURS WITH ONE OPERATOR AND ASSISTANT, THE MAJORITY OF WHICH IS TAKEN UP BY THE DOUBLE PLATE HANDLING REQUIRED BY THE MACHINE DESIGN.

IN MOST CASES, THE EXCESS FLAT AND FLAT END MUST BE REMOVED AND FOLLOWING GAP CLOSING AND LONGITUDINAL SEAM WELDING OPERATION, THE SHELL IS RE-ROLLED WITH A TOLERANCE OF LESS THAN 1% DEVIATION ON DIAMETER..

SPIRALLING IS A PROBLEM WHICH IT IS DIFFICULT TO RECTIFY AND ADDS CONSIDERABLE EXTRA TIME IN PRODUCTION.

THE MACHINIEWAS PURCHASED IN 1969 AT A COST OF BETWEEN S50.000 AND S60.000.00 WHICH WAS DEPRECIATED OVER 10 YEARS.

[9] CASE STUDY

[5] RDL BRITISH STEEL CORPORATION.

C. DYSON
General Manager

THE COMPANY PRODUCES TUBULARS FOR THE OFFSHORE INDUSTRY. AMONGST THEIR RANGE OF EQUIPMENT IS A HYDRO-MECHANICAL 4-ROLLER PLATE BENDING MACHINE WITH A NOMINAL CAPACITY OF 3000 X 75 MM IN 50D STEEL, 60,000 PSI YIELD.

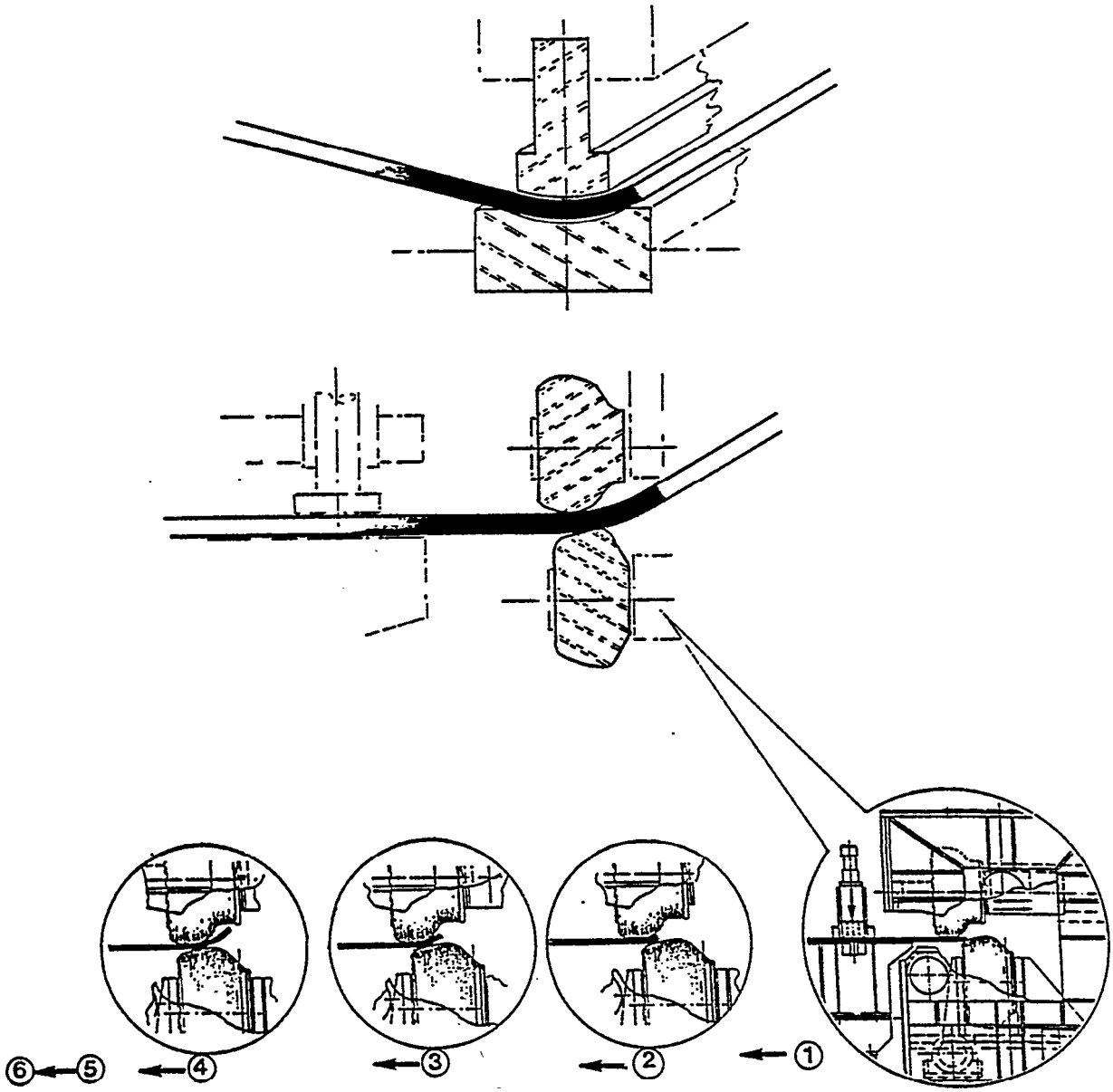
TAKING A TYPICAL CAN 3000 X 70 MM ROLLED TO A DIAMETER OF 1600 MM THE FLOOR TO FLOOR TIME, EXCLUSIVE OF TACKING, WILL BE IN THE REGION OF 25/30 MINUTES, ONE OPERATOR ONLY REQUIRED.

TOLERANCE REQUIRED AND ACHIEVED 1S LESS THAN 5 JAM BETWEEN THE SMALLEST AND LARGEST DIAMETERS AND THEREFORE CALIBRATING FOLLOWING LONGITUDINAL SEAM WELDING OPERATION IS REQUIRED.

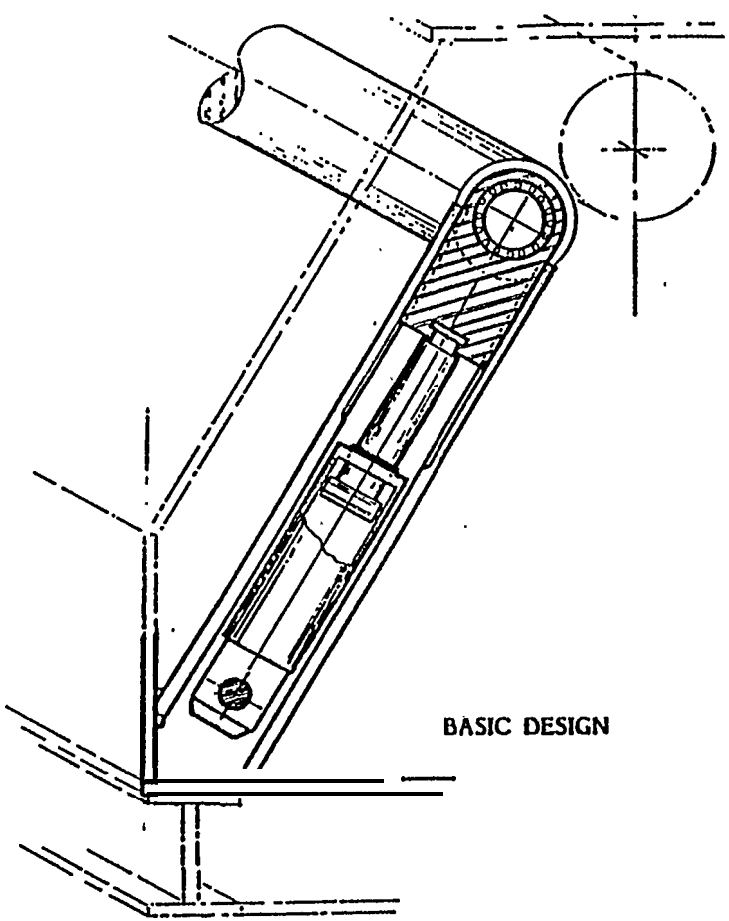
THE MACHINE IS RELIABLE AND AVAILABLE FOR USE OVER 90% OF THE TIME, YEARLY MAINTENANCE, 2 TO 3 DAYS.

THE MACHINE WAS PURCHASED IN 1972 AT A COST OF APPROXIMATELY S160,000.00 - DEPRECIATION FIGURES NOT AVAILABLE.

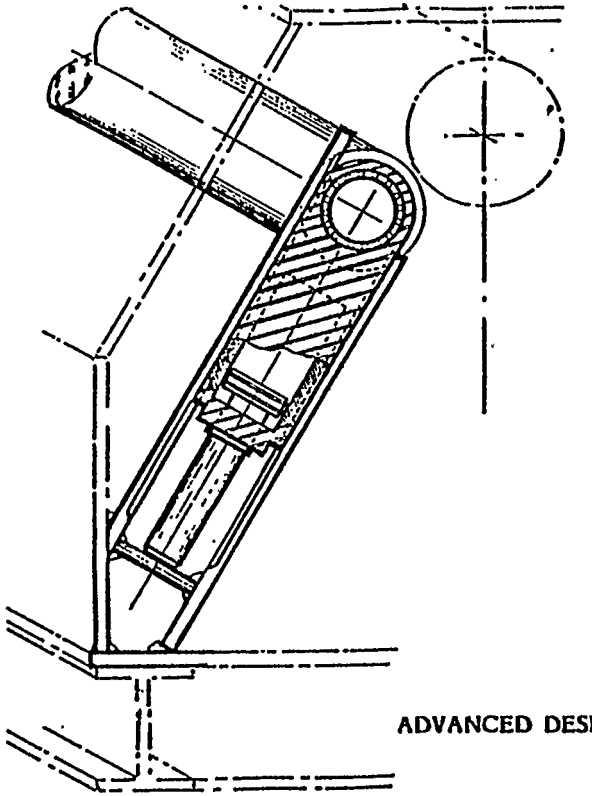
AUXILIARY EQUIPMENT FOR SYMETRIC ROLLING



ALTERNATIVE PLATE EDGE-CURVING METHODS



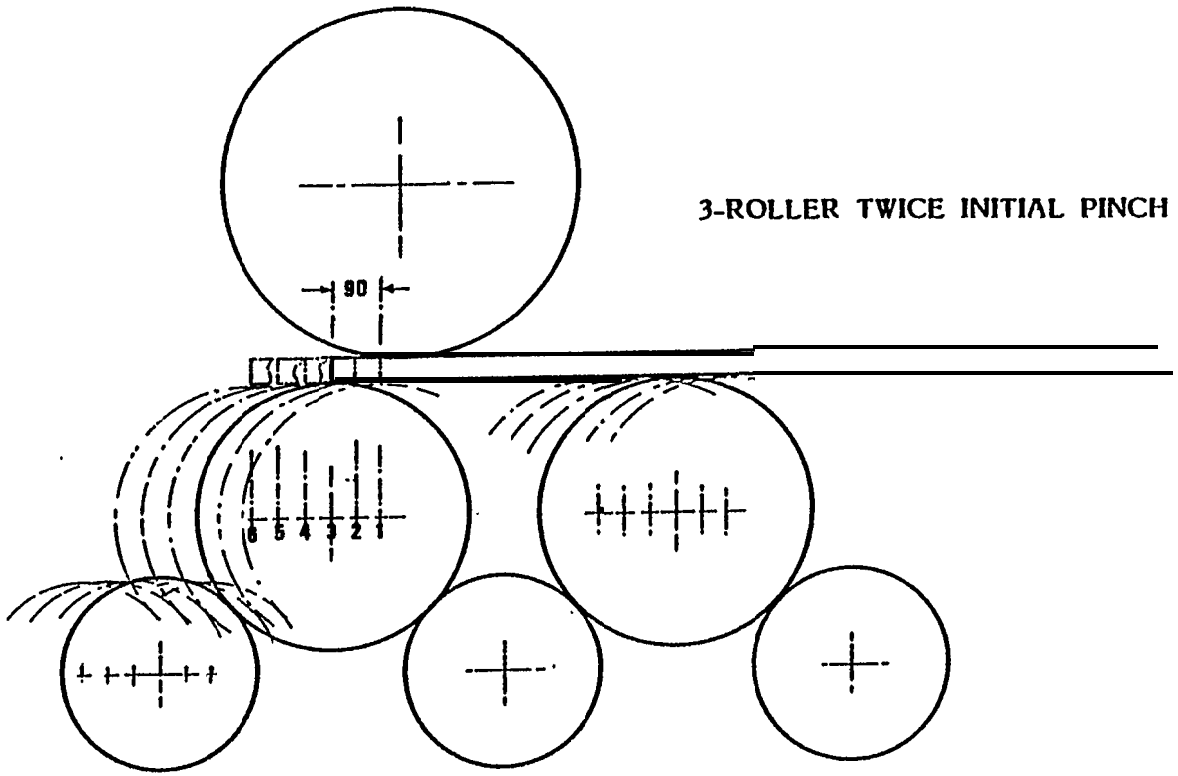
BASIC DESIGN



ADVANCED DESIGN

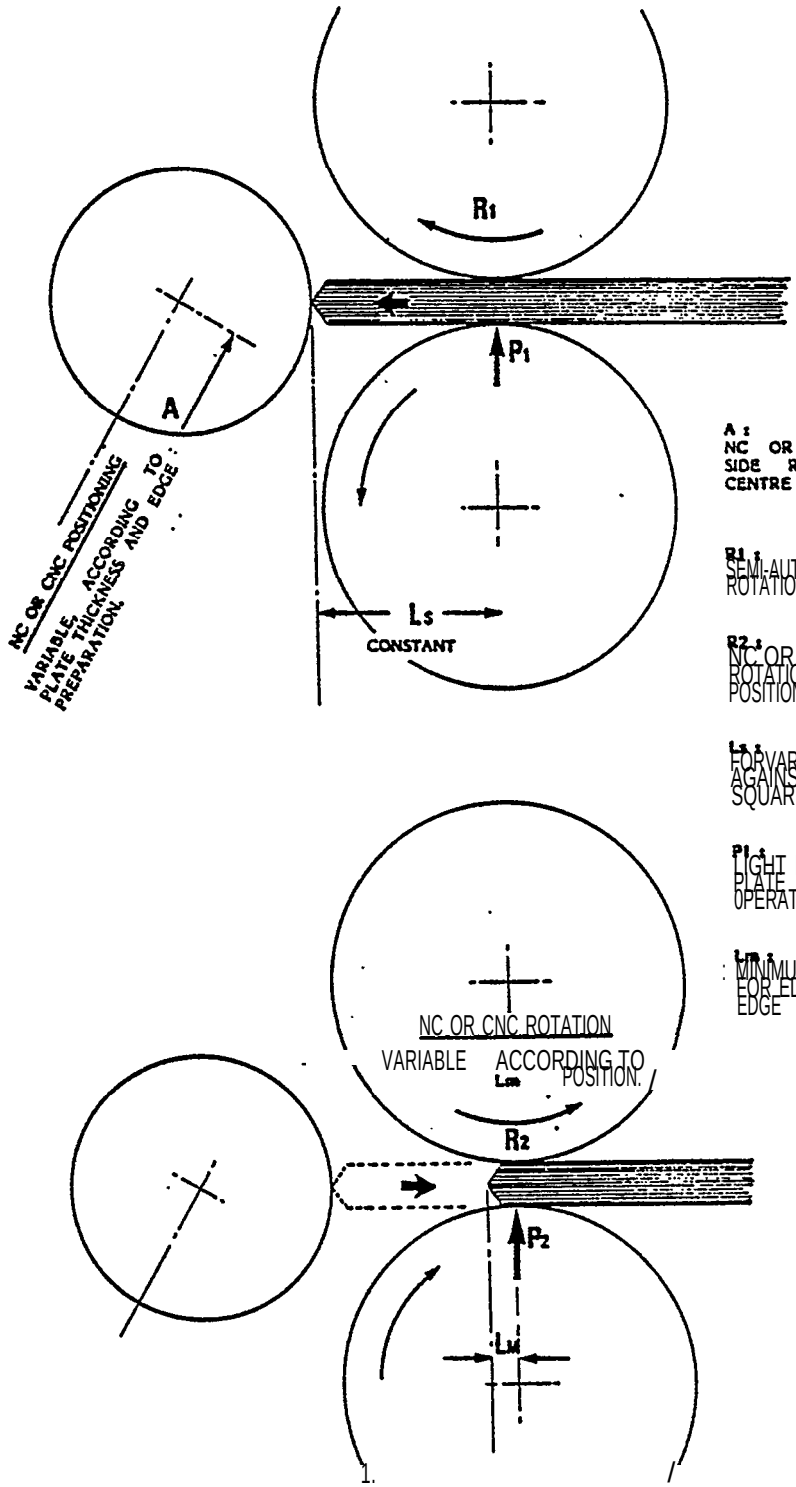
TO ACHIEVE AND MAINTAIN ACCURACY IN PLATE ROLLING, FIRM ROLLER SO N R OR MAINTAINING SET POSITION IS PARAMOUNT.

4-ROLLER SYSTEM OF HYDRO-MECHANICAL CONSTRUCTION



3-ROLLER TWICE INITIAL PINCH CONSTRUCTION

EDGE SETTING WITH POWER UTILIZATION - VARIABLE GEOMETRY IN ROLLER SETTING
BUT CONSTANT HEIGHT OF LOWER ROLLERS

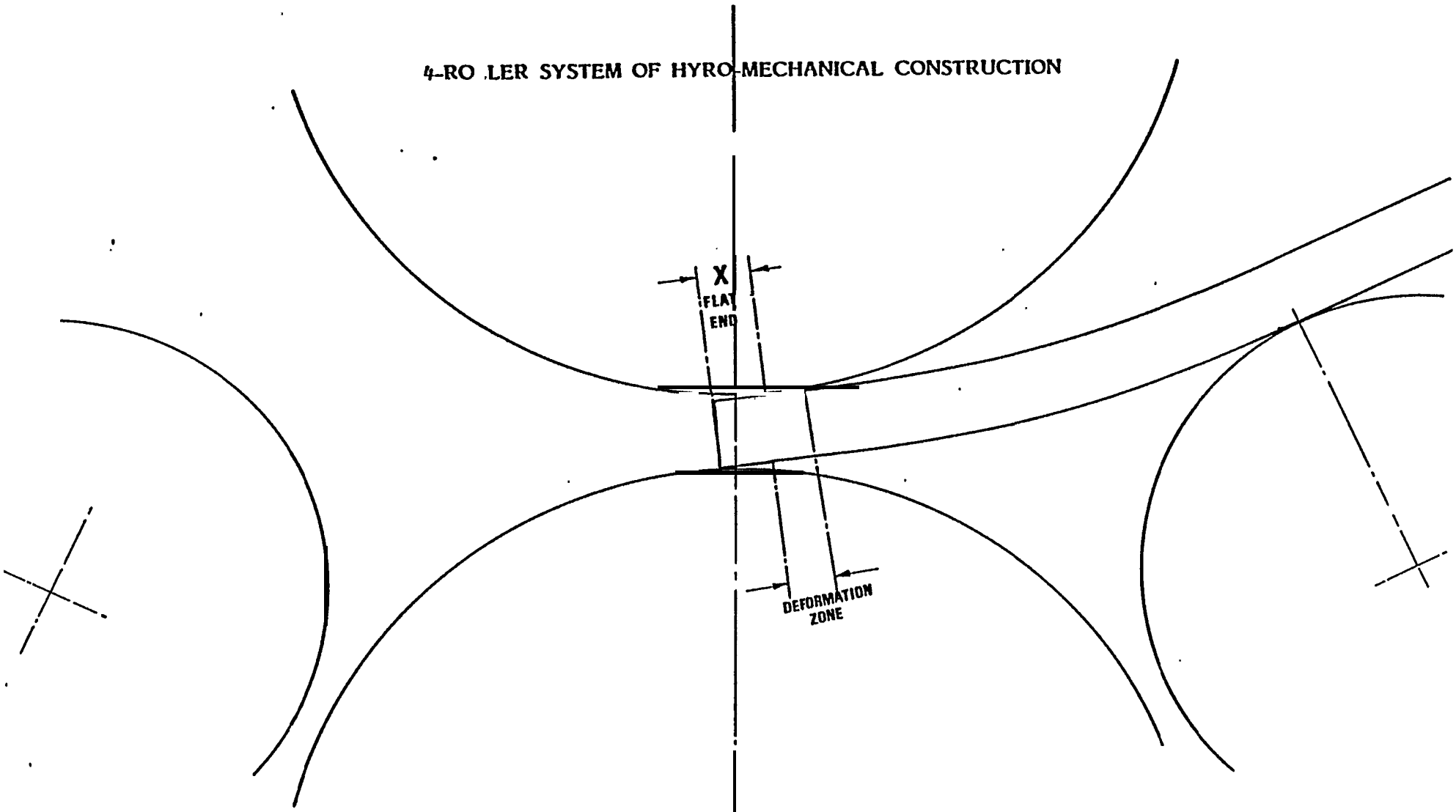


1.

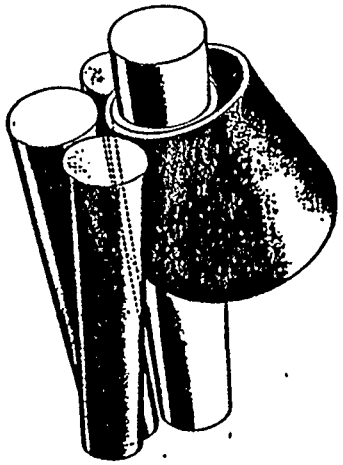
SAFETY AT WORK

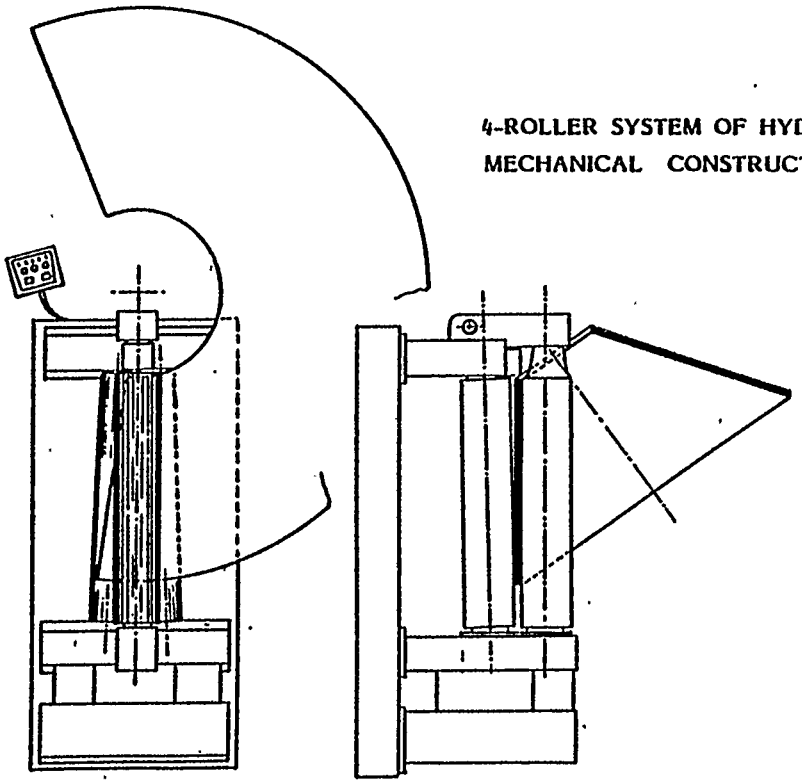
ROLLER SETTING AND ROTATION CONTROL

4-ROLLER SYSTEM OF HYRO-MECHANICAL CONSTRUCTION



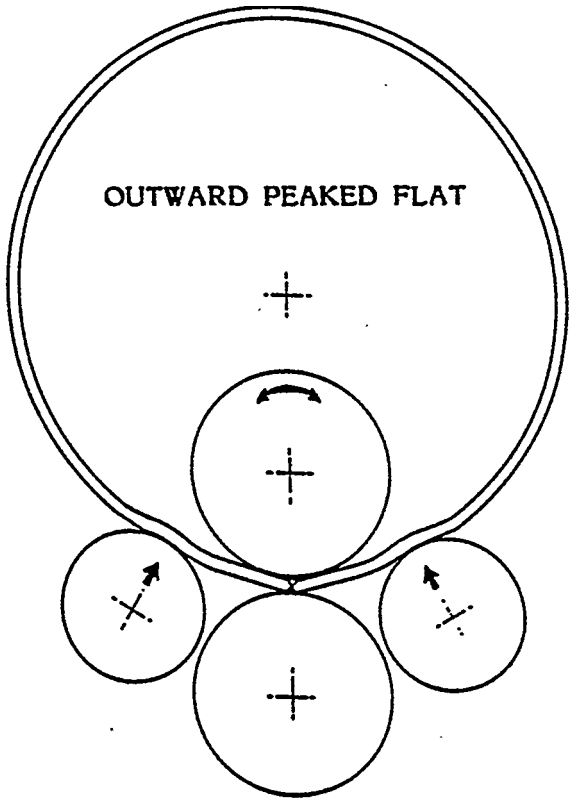
EDGE SETTING WITH ESTABLISHED FLAT BY DESIGN OF APPROACH ANGLE OF BENDING ROLLER AND PRESSURE WITHIN THE SYSTEM



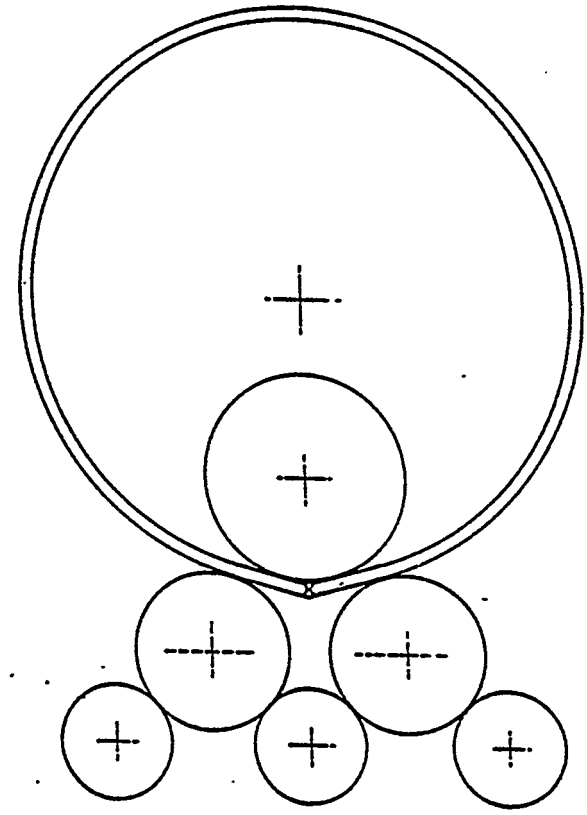


4-ROLLER SYSTEM OF HYDRO-MECHANICAL CONSTRUCTION

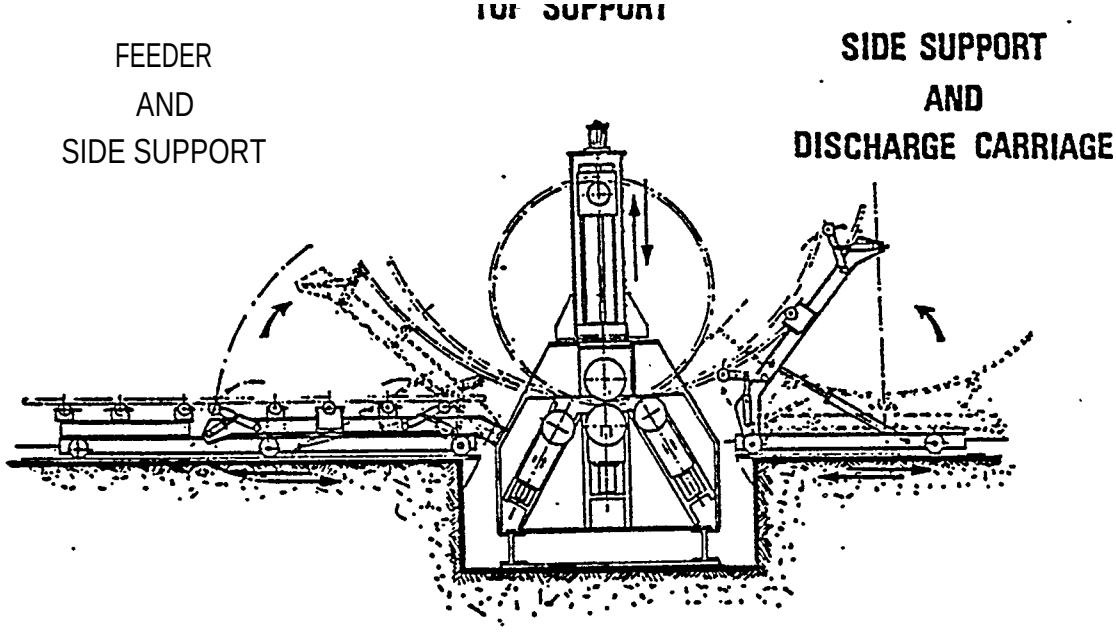
CONE ROLLING ON A 4-ROLLER MACHINE IS A CONINUOUS OPERATION FROM START TO **FINISH, INCLUSIVE OF EDGE SETTING. ON COMPLETION OF WORK, DRESSING OF** SMALL END IS **REQUIRED.**



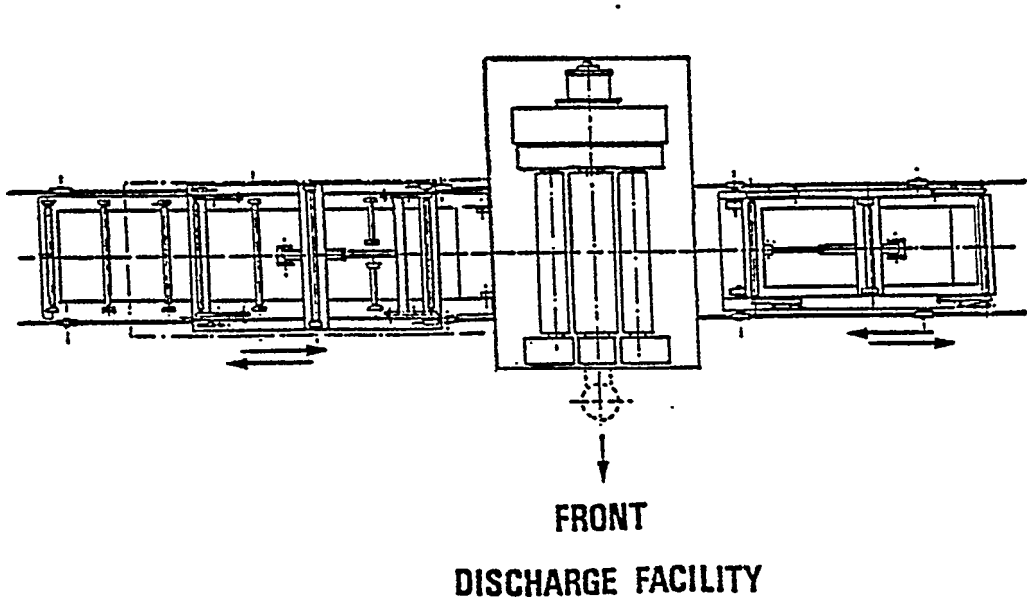
CORRECTION ON 4-ROLLER SYSTEM POSSIBLE

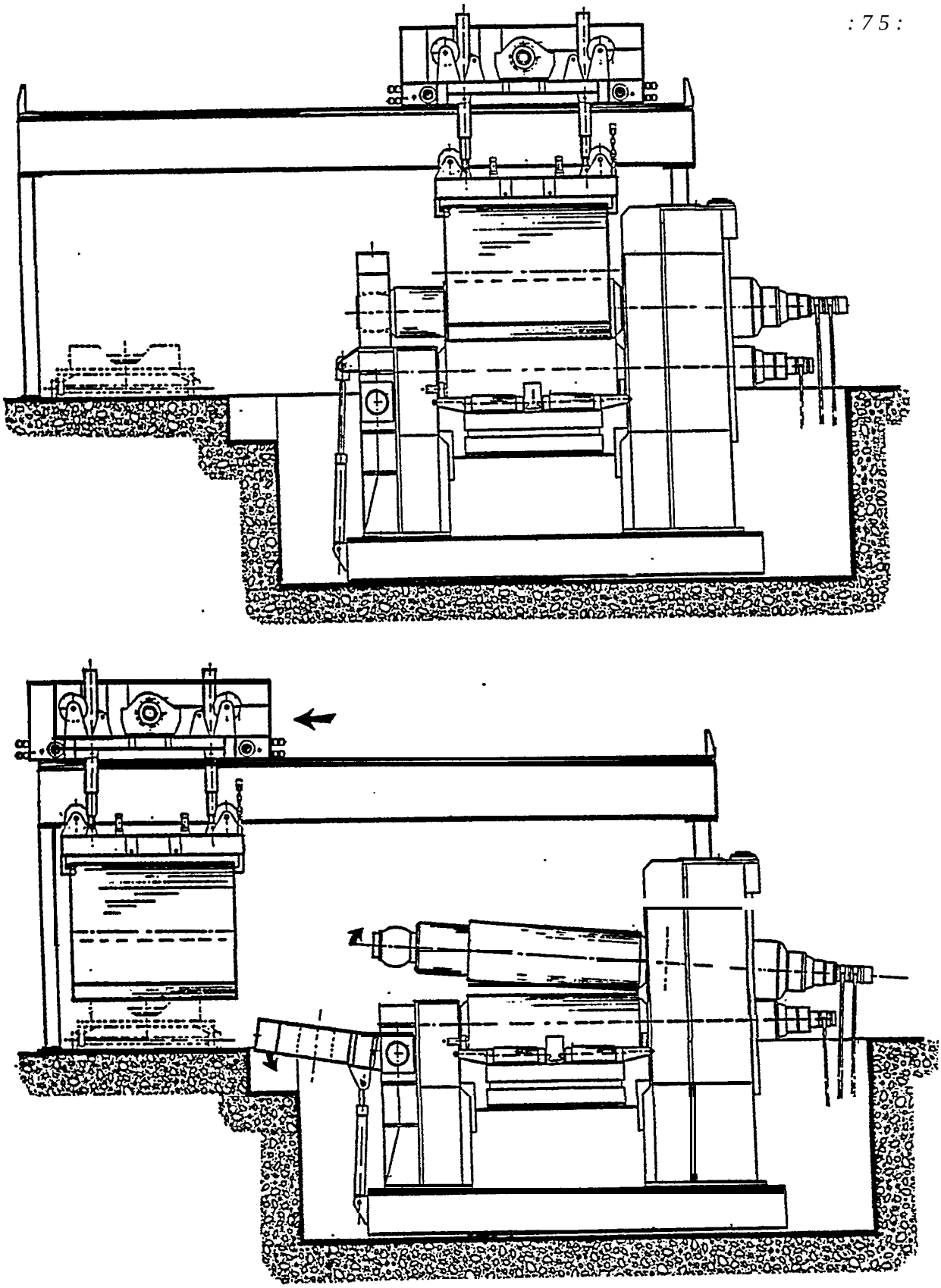


CORRECTION ON 3ROLLER TWICE INITIAL PINCH SYSTEM NOT POSSIBLE



MECHANISED PLATE FEEDING, SHELL/SHELL-SEGMENT SUPPORTING MECHANISM WITH FRONT OR LATERAL DISCHARGE FACILITY ACCORDINGLY.





PURPOSE BUILT CRANE MECHANISM FOR DISCHARGE OF MASS PRODUCED SMALL AND MEDIUM SIZED SHELLS [CANS]

APPENDIX I

IT WAS NOT THE 0BJECT OF THIS FEASIBILITY STUDY TO DEAL WITH PRODUCTION LINES AND PURPOSE BUILT MACHINERY FOR MASS PRODUCTION OF TUBULARS, BUT THE AUTHOR WISHES TO CALL ATTENTION TO THE ADAPTABILITY OF SYMETRIC/PYRAMID ROLLING METHOD WITH THE USE OF AUXILIARY EQUIPMENT AS MENTIONED ON PAGE 20.

Quote THE MACHINE OF ADVANCED DESIGN WITH 3-ROLLER DRIVEN, PRESTRESSED TOP ROLLER COUPLED WITH AUXILIARY EDGE CURVING EQUIPMENT IS MOST SUIITABLE FOR MEDIUM DIAMETER PIPE PRODUCTION. Unquote:

1 : A MOBILE EDGE SETTING UNIT.

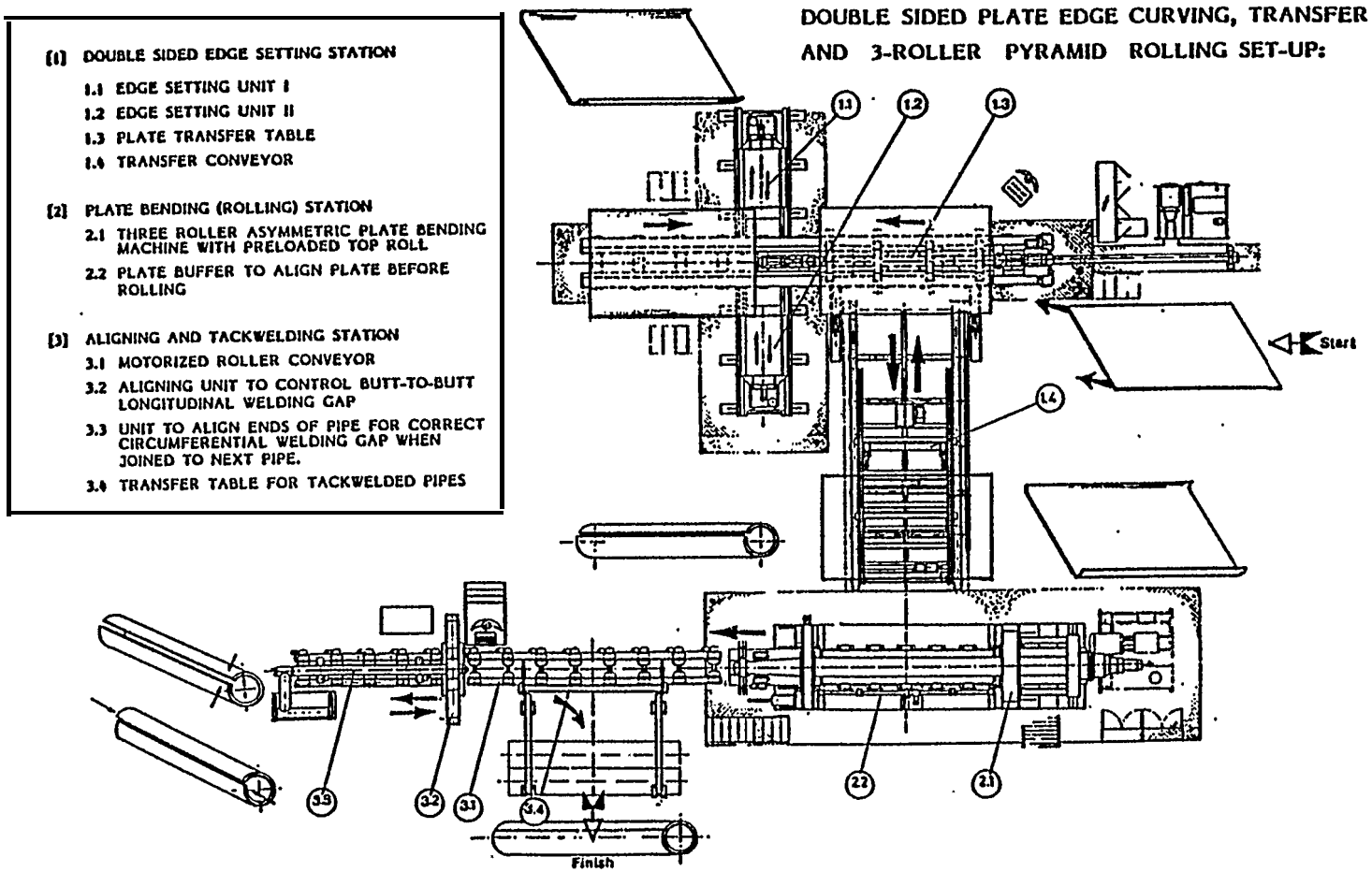
2 : A 3-ROLLER PLATE BENDING MACHINE OF ADVANCED DESIGN.

3 : AN INTEGRATED TRANSPORT AND TRANSFER SYSTEM FOR ABOVE.

TECHNICAL DATA :

PIPE LENGTH - MAXIMUM :	20 FEET
PIPE DIAMETER BETWEEN	2 and 6 INCHES
PLATE THICKNESS BETWEEN	¼ and 2.1/8 INCHES.

DOUBLE SIDED PLATE EDGE CURVING, TRANSFER AND 3-ROLLER PYRAMID ROLLING SET-UP:



[1] DOUBLE SIDED EDGE SETTING STATION

- 1.1 EDGE SETTING UNIT I
- 1.2 EDGE SETTING UNIT II
- 1.3 PLATE TRANSFER TABLE
- 1.4 TRANSFER CONVEYOR

[2] PLATE BENDING (ROLLING) STATION

- 2.1 THREE ROLLER ASYMMETRIC PLATE BENDING MACHINE WITH PRELOADED TOP ROLL
- 2.2 PLATE BUFFER TO ALIGN PLATE BEFORE ROLLING

[3] ALIGNING AND TACKWELDING STATION

- 3.1 MOTORIZED ROLLER CONVEYOR
- 3.2 ALIGNING UNIT TO CONTROL BUTT-TO-BUTT LONGITUDINAL WELDING GAP
- 3.3 UNIT TO ALIGN ENDS OF PIPE FOR CORRECT CIRCUMFERENTIAL WELDING GAP WHEN JOINED TO NEXT PIPE.
- 3.4 TRANSFER TABLE FOR TACKWELDED PIPES

LINE PIPE PRODUCTION-(EDGE SET BY ROLLING)

SINGLE SIDED PLATE EDGE CURVING, FOR 3-ROLLER ADVANCED PYRAMID ROLLING SYSTEM.

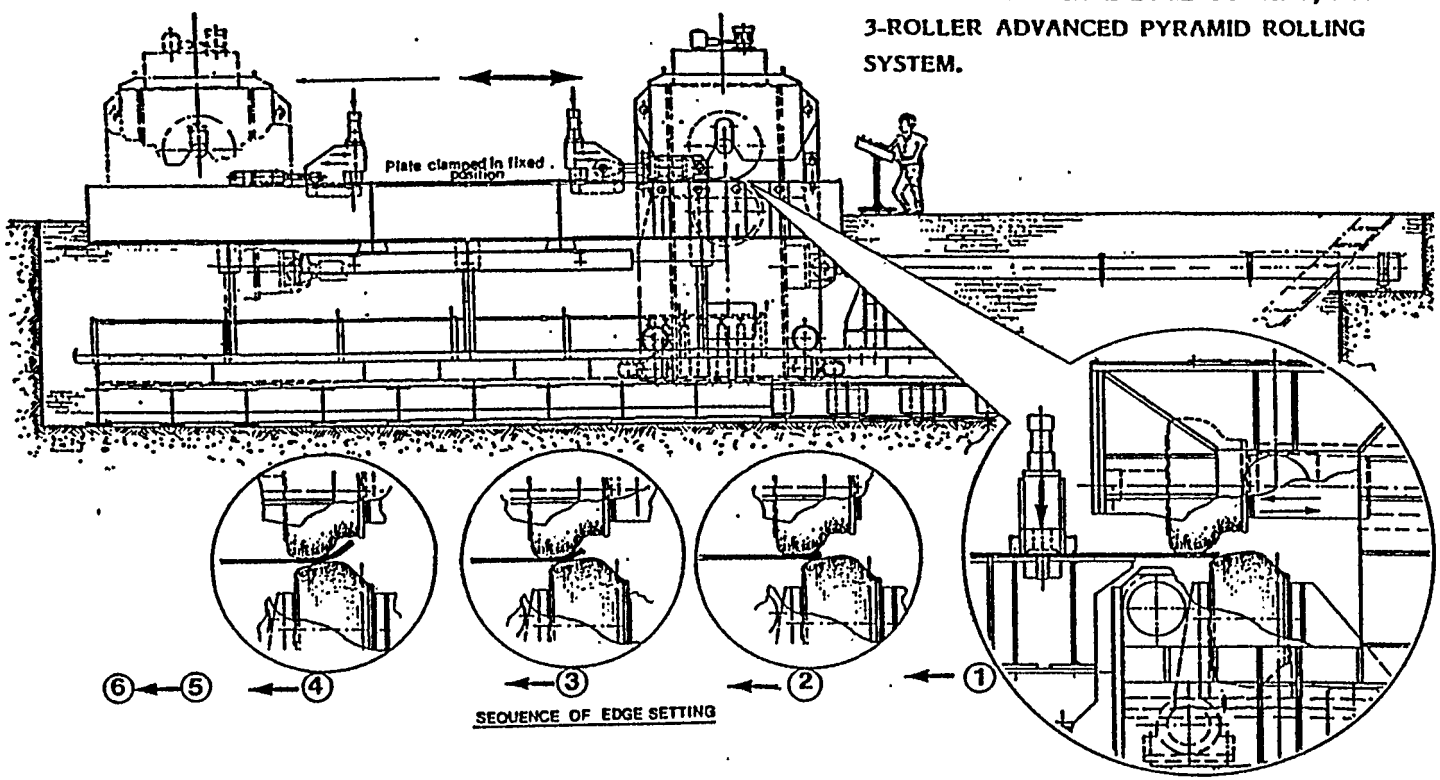
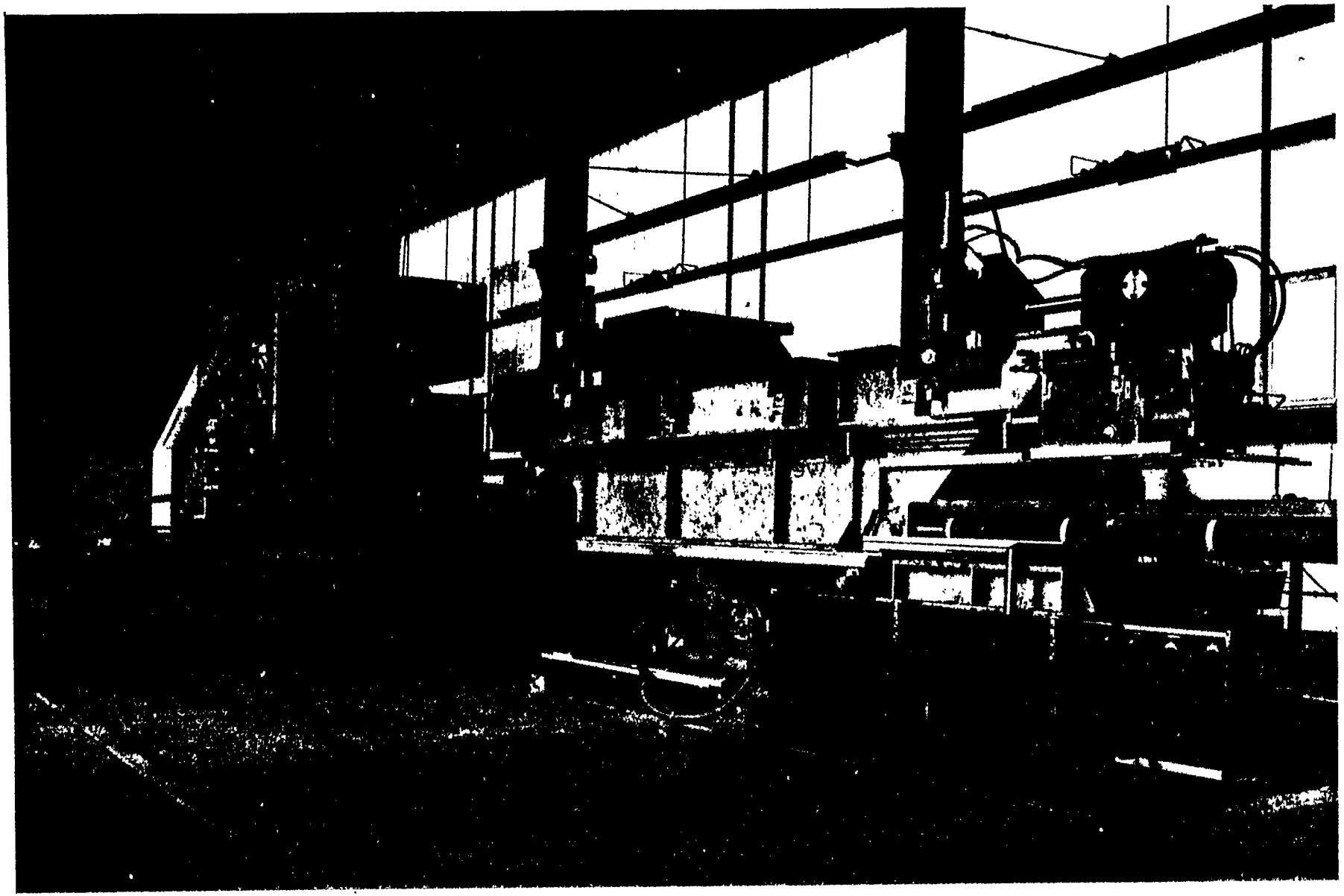


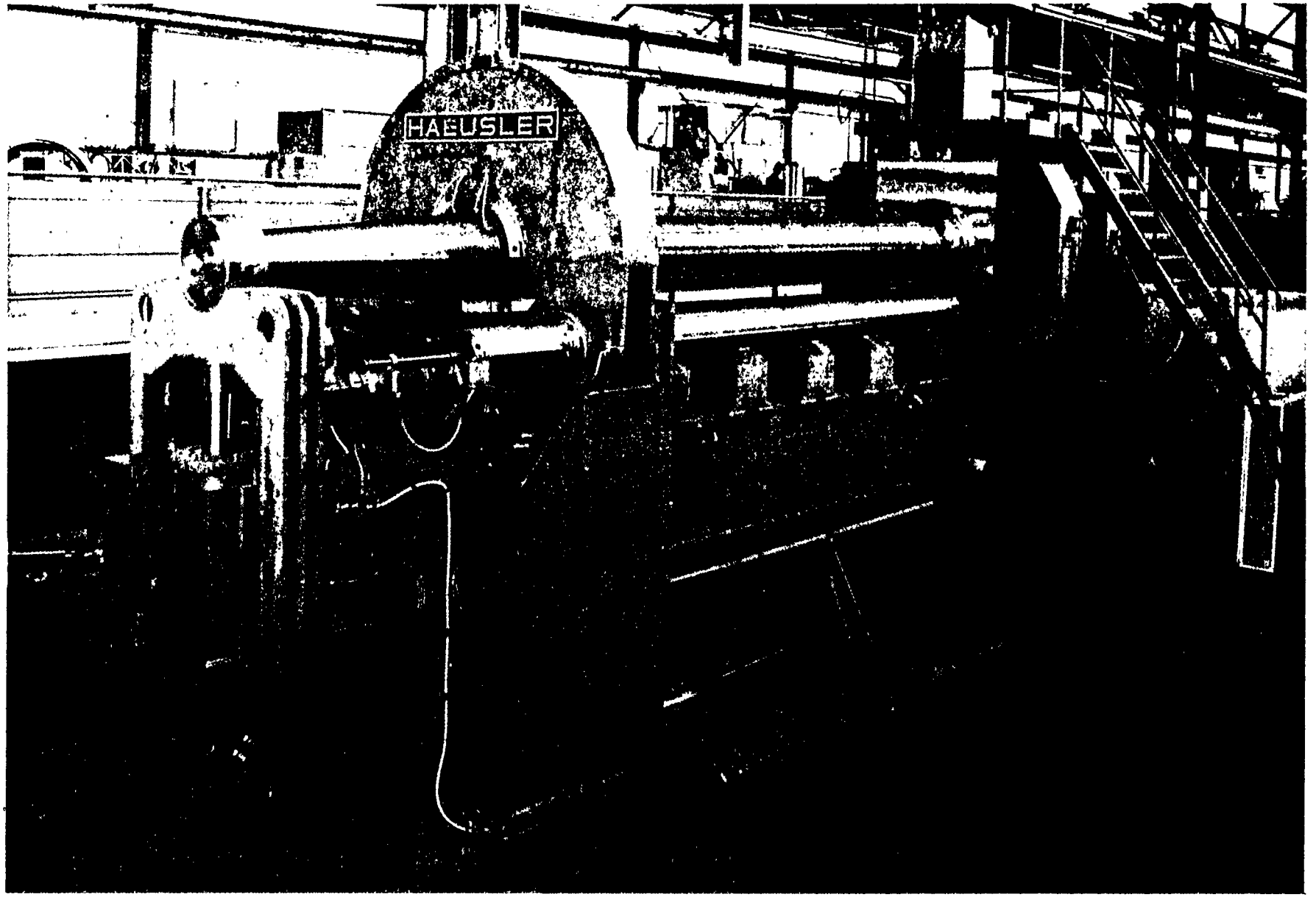
PLATE EDGE SETTING MACHINE



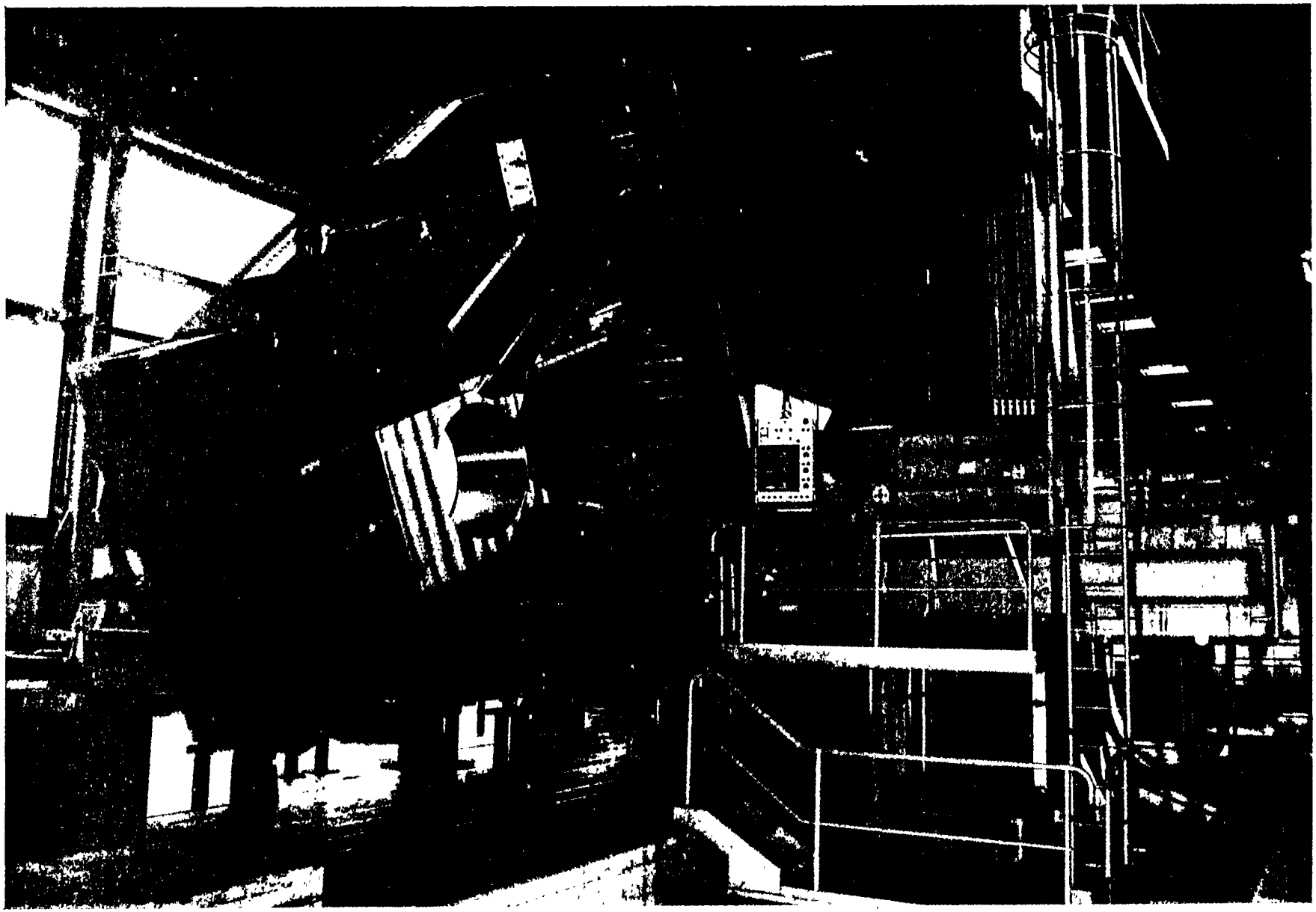
DOUBLE SIDED PLATE EDGE-SETTING MACHINE

PHOTOGRAPHS OF 3 AND 4 ROLLER MACHINES

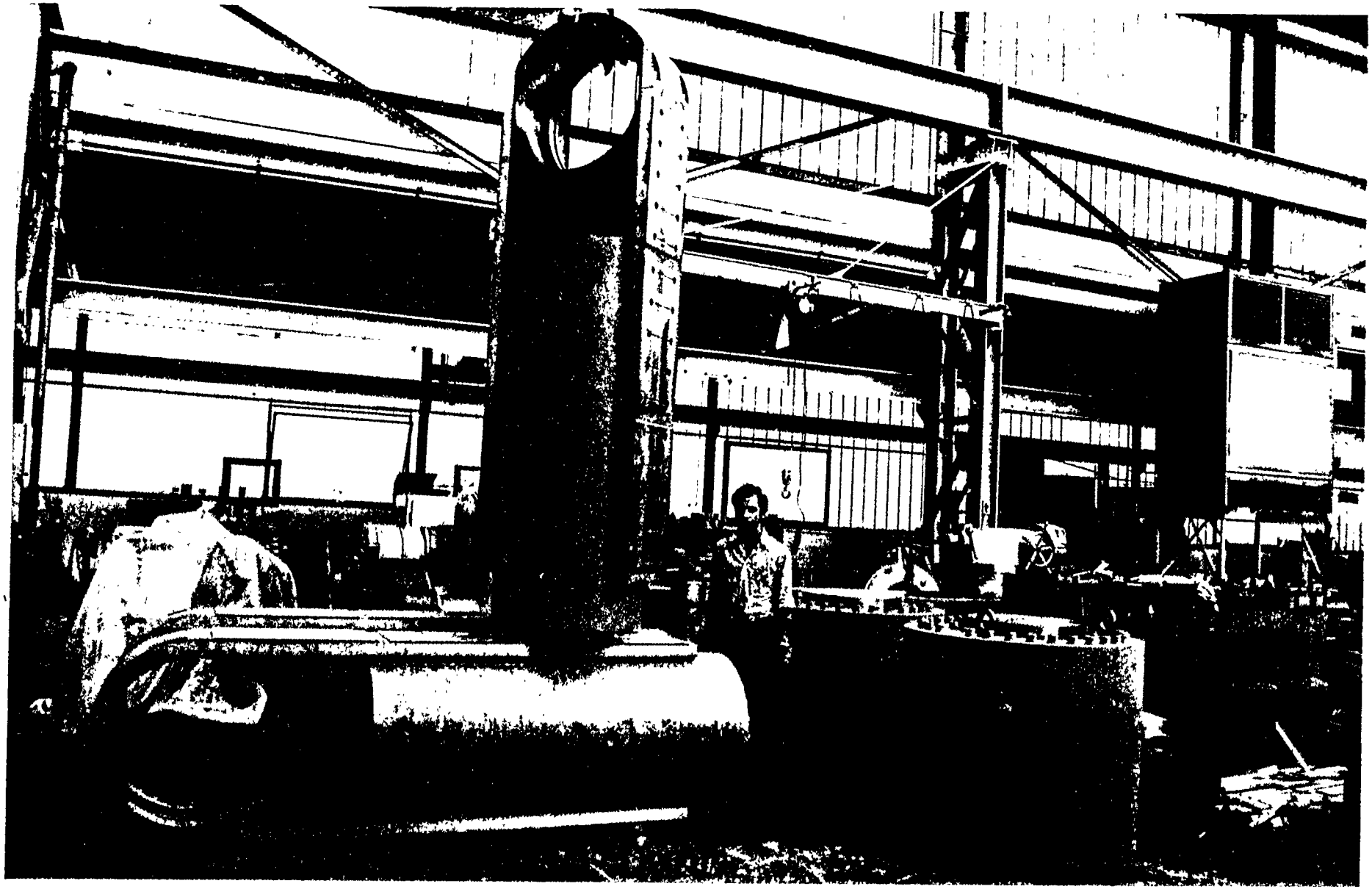
AND FEEDING/SUPPORT- CARRIAGES



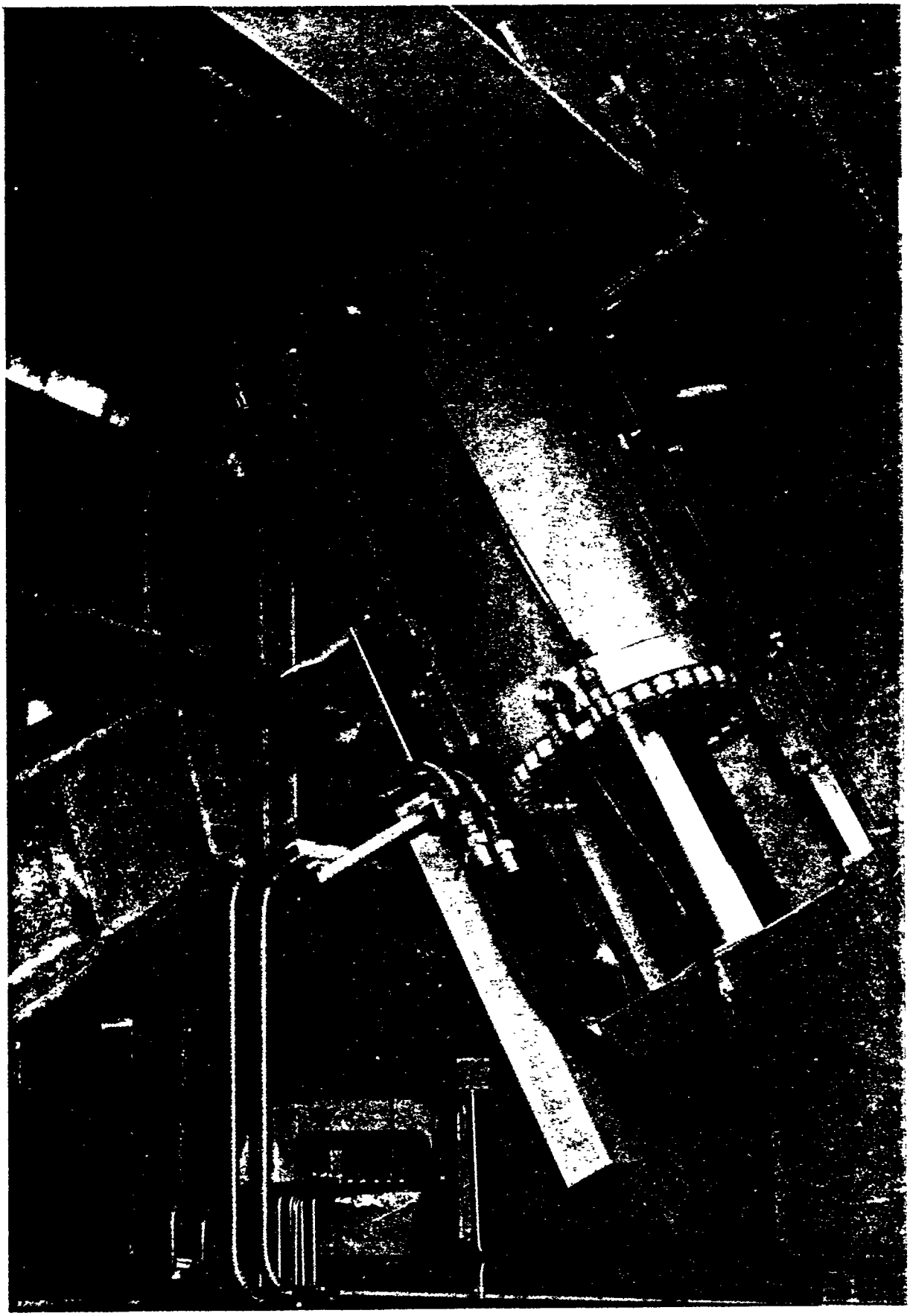
R PYRAMID PLATE BENDING MACHINE OF ADVANCED DESIGN



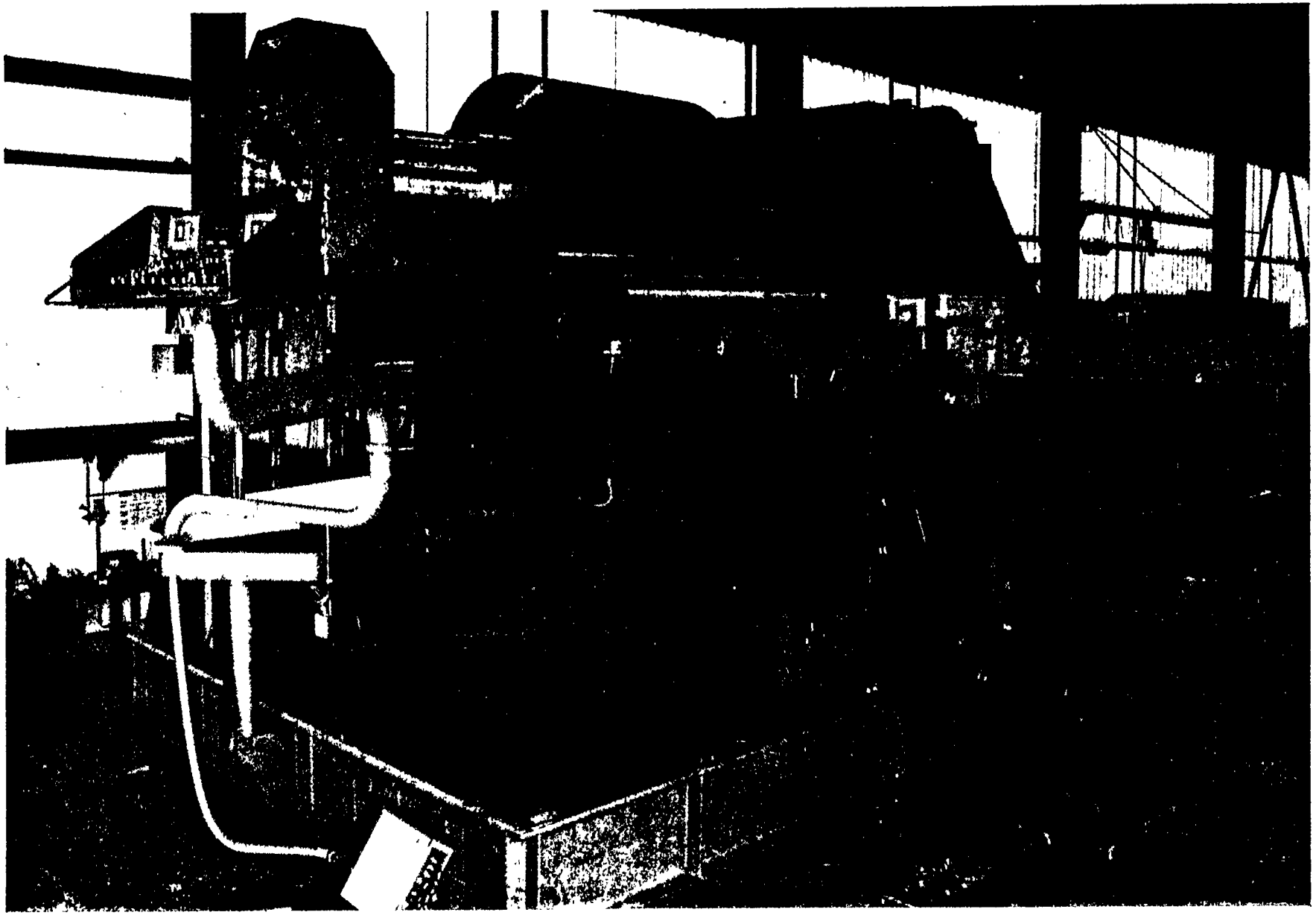
WELDED STEEL MACHINE. FRAME BEING MACHINED [4-ROLLER TWIN INITIAL PINCH TYPE MACHINE]



ROLLER POSITIONING HYDRAULIC RAM

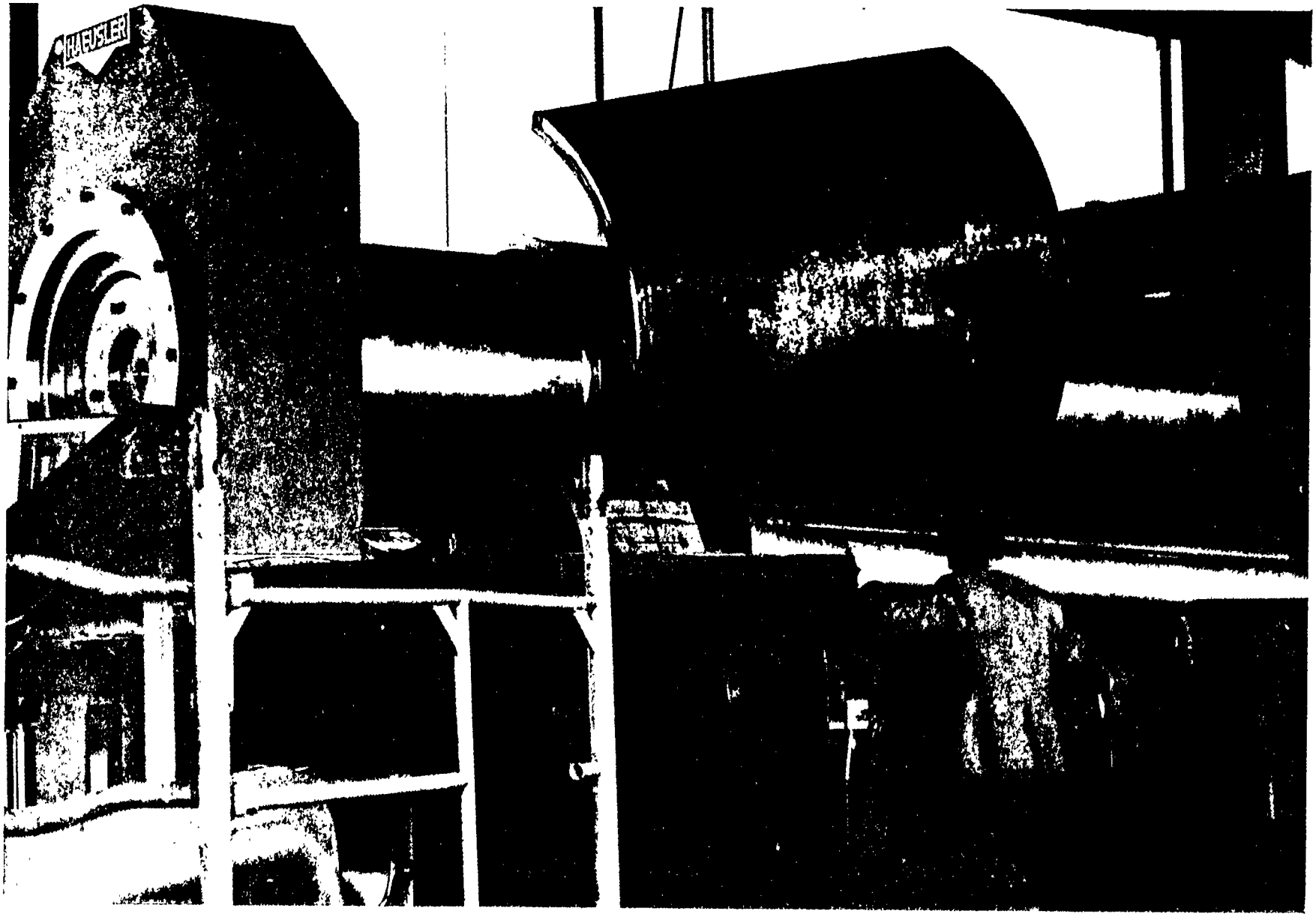


ROLLER POSITIONING HYDRAULIC RAM
(4 ROLLER TWIN INITIAL PINCH TYPE MACHINE)

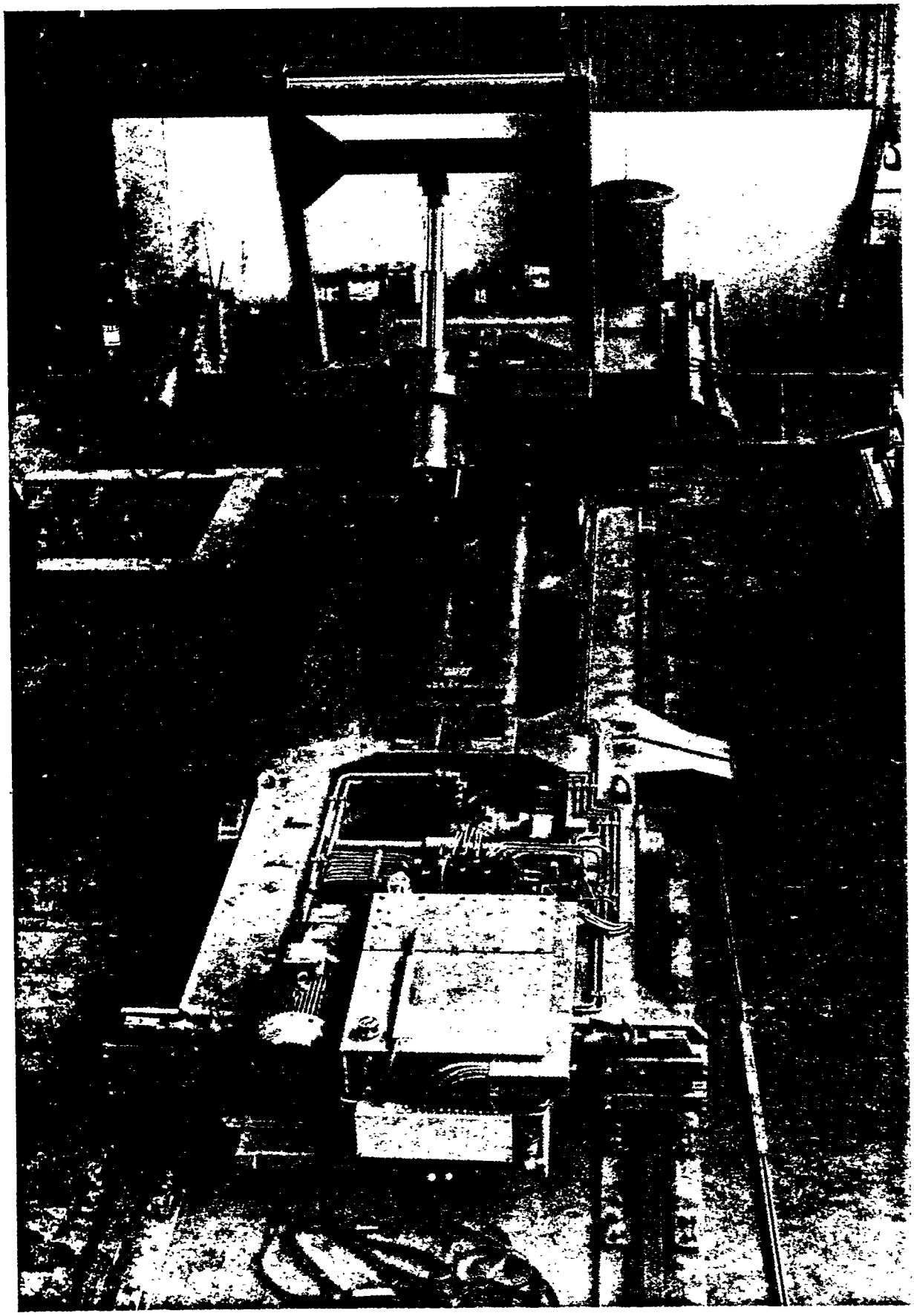


4-ROLLER TWIN INITIAL PINCH TYPE MACHINE VRMJ : CAPACITY 3500 x 150 MM

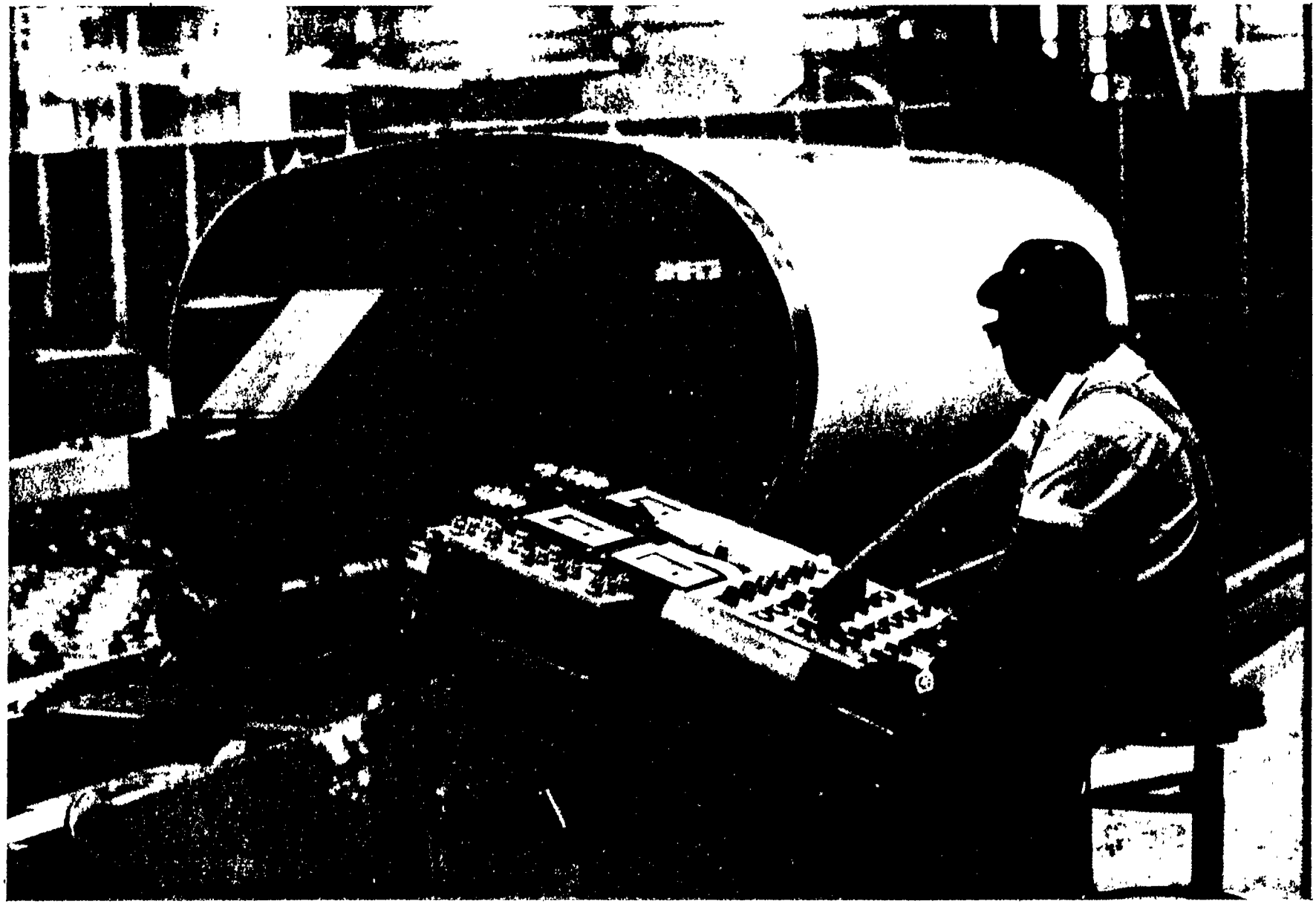
4-ROLLER TWIN INITIAL PINCH TYPE MACHINE [VRM] : CAPACITY 3500 x 150 MM
WITH FEEDER AND SIDE SUPPORT



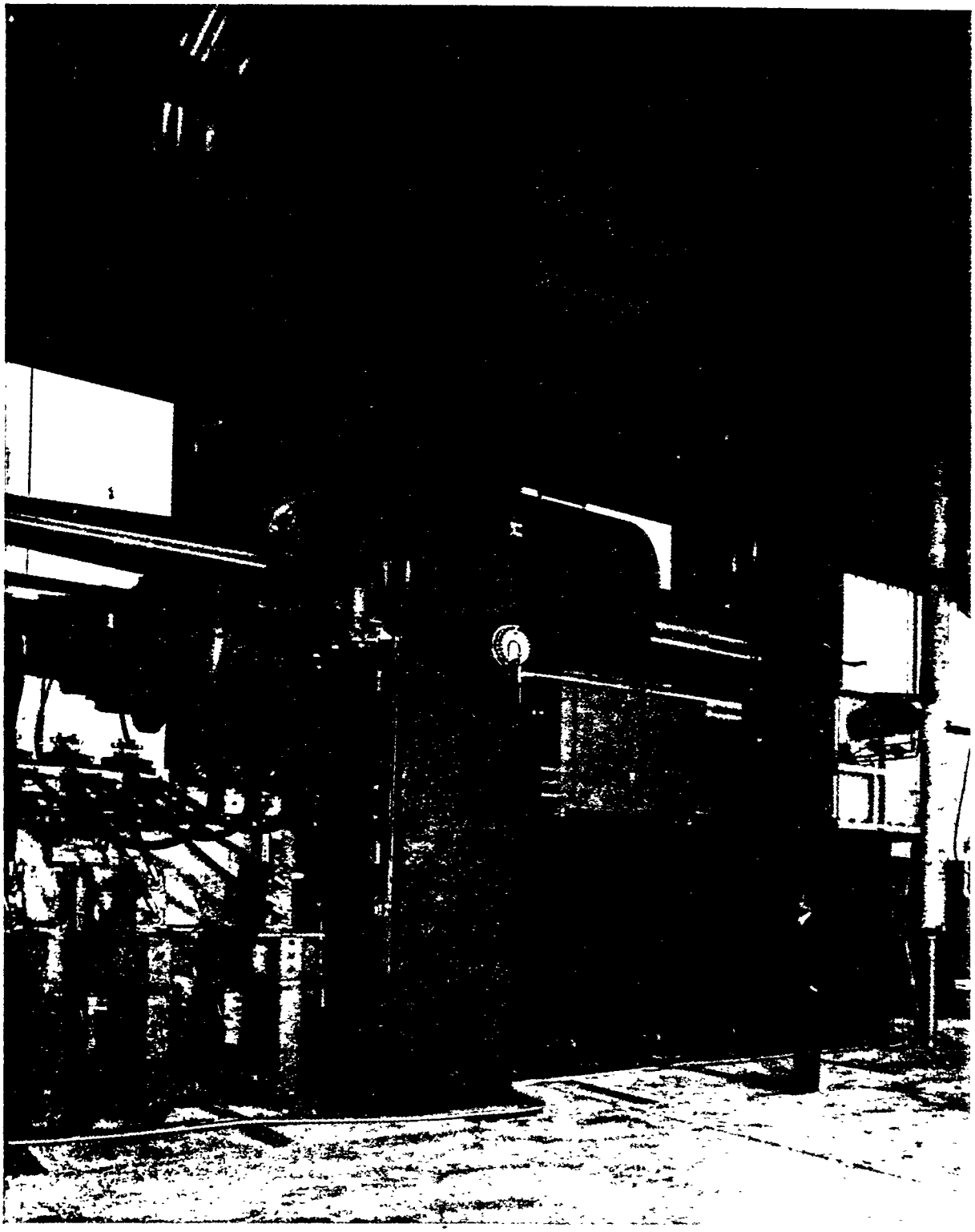
CONE ROLLING ON 4 ROLLER TWIN INITIAL PINCH TYPE MACHINE



SIDE SUPPORT AND DISCHARGE CARRIAGE



AUTOMATIC ROLLING OF OVAL TANK SECTION [4-ROLLER MACHINE]



3 ROLLER TWICE INITIAL PINCH TYPE MACHINE (HDR)

CAPACITY 4000 x **90 MM**